THE ENGINEER

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THREAT TO THE STEEL INDUSTRY

Neither of the two major political parties in this country, judging by recent by-election results, is particularly popular with the electorate at present. Many voters by abstention or by voting Liberal seem to be saying " a plague o' both your houses." The reason is not far to seek. The two parties seem, in some of their actions, more concerned to serve factious party ends than to consider national needs. One of the more irresponsible and factious actions of the Labour party is to suggest that were it to return to power at the next General Election, likely to take place within eighteen months, it will renationalise the iron and steel industry. Recently, the chairmen of a number of steel companies have referred to the damage done by the uncertain financial future thus created for the industry and at the annual general meeting of the British Iron and Steel Federation last week Sir Andrew McCance, its president, also referred to the subject. He sought, but could not find, any justification for renationalisation of the industry. Since the war, output has risen by 75 per cent, productivity by 40 per cent, and an average of £2,000,000 a week is being spent on development. Prices compare favourably with those ruling abroad. Employee relationships are excellent. Development plans have been and continue to be discussed and agreed with the Government of the day, whatever its political complexion. The industry operates under the supervision of a Board with the statutory general duty of promoting the efficient, economic and adequate supply under competitive conditions of iron and steel products ; and that Board has strong powers, particularly over development and prices. Only in the field of finance could Sir Andrew find any justification for arguments that the industry ought to be nationalised. But, he pointed out, financial difficulties to-day are primarily caused by the threat of nationalisation which makes investors unwilling to purchase shares in the industry. Moreover, the industry, despite those difficulties, is proceeding with plans for a rate of expansion higher than ever before, confident that it will be able to finance them.

Within limits, the Socialist case can be understood. Socialists more strongly than Conservatives appreciate that it is not a necessary consequence of the existence of a prosperous private enterprise that the nation will be well served by it. High profits, for example, can, under certain circumstances, be earned by restricting production and selling at high prices. A greater output at higher productivity, which would serve the nation better, may merely increase the responsibilities of a firm without enlarging its profits. Again, private enterprise, by solely pursuing high profits, may neglect to supply, or make it impossible for any other private enterprise to supply, a public need. For example, after the first world war " pirate " buses appeared on the streets of London to compete with the old London General Omnibus Company. Naturally, the " pirates " chose to operate on the more profitable routes, leaving the L.G.O.C. to maintain other services operated at negligible profit or actually at a loss. It was to meet that impossible situation that the London Passenger Transport Board was set up. But nationalisation is not the only answer ; each industry needs to be considered separately. As far as an industry such as steel is concerned what is needed is to ensure by some machinery that it meets adequately all the needs of all the other industries it serves and that it does not consider too exclusively profit-making alone, but takes into account the national and social consequences of its actions. The Labour party, when it attained power after the war, attempted to secure those ends by nationalising the industry. The Conservative party rejected that solution, but admitted the existence of the problem. It set up the Iron and Steel Board to supervise the industry. It is surely factious now on the part of the Labour party to propose to renationalise the industry. Upon the principle that so powerful an industry, and one upon whose prosperity the nation is so dependent, must be supervised nationally both political parties are agreed. So, too, is the industry itself. What purposes not served by the Iron and Steel Board would be secured by nationalisation ? The only purpose that we can see appears enviously factious. It is to prevent private individuals, by risking investing their money in a vigorous and prosperous industry, from making private gains. If the Labour party really feels the nation has too little control over the industry surely its remedy is not nationalisation, but amendment, in a spirit of compromise, of the present set-up. Certainly the industry is not to be blamed for a situation in which various chairmen have thought it desirable to speak out in its defence.

GREAT ROAD CONFERENCE

When in November of last year the Institution of Civil Engineers held a Conference on " The Highway Needs of Great Britain " it was easy enough to recognise that it was an important occasion. Now that the Institution has published the proceedings of the Conference as a separate volume it has become even more apparent what a wealth of authoritative material about every detail of highway planning, construction and maintenance was offered to the members. We doubt whether ever before the full facts about road transport and its importance to the country have been so admirably presented. The Government is now publicly drawing attention to the amount of road construction going forward. The Minister of Transport, in particular, makes a point of attending inaugurations and every other kind of ceremony connected with roads ; and of drawing attention to the road programme at every opportunity. Backhandedly his enthusiasm is encouraging. For his determination to demonstrate to the public how

fine a programme of road development is in progress may well stem from a conviction within his Ministry that the programme falls well behind the needs !

The importance of roads was well brought out at the Conference by the statistics that some 13½ per cent of the national income is spent on road transport, that goods transport accounts for about half that figure, and that 50 per cent of the mileage of passenger traffic is on business. Several estimates were made of losses due to traffic delays on our inadequate roads. Even the most conservative amounted to £265 million annually. On the question of what would be an adequate road system much depends upon estimates of the rate at which road usage is increasing. There are some 7,000,000 vehicles in use at the present time. Since 1946 they have increased in numbers at a rate of about 8·2 per cent compound per year and it was suggested at the conference that an 8 per cent increase of traffic results in a 14 per cent increase in losses due to delays. At the present rate of increase there will be 14,000,000 vehicles on our roads in about nine years time. But certain contributors to the Conference regarded it as improbable that expansion would continue at so high a rate. Nevertheless there is much wisdom in the remark of Sir Herbert Manzoni in summing up the Conference that " when we build a road we expect it to be there for very much more than nine years." The basis of road design should surely be, not the requirements some ten or so years ahead, but an estimate of the ultimate capacity required. That estimate can be based upon some such assumption, conservative enough by American standards, that there will in the not distant future be at least one vehicle per family in this country. On the basis of that estimate some three to four times as much traffic as at present must be expected on the roads as a whole within twenty years or so and possibly substantially more on that one per cent of roads which now carries 25 per cent of the traffic. Whatever the grounds for estimation there seemed general agreement at the Conference that the cost of providing adequate roads, within cities as well as in rural areas, would reach between £3500 million and £4400 million. But that figure has little meaning unless a timetable is attached. How quickly should the work be done ? Here it is notable that the lowest rate of expenditure suggested at the Conference was £175 million per annum. Sir Herbert suggested that if traffic is likely to double itself within ten years a rate approaching £350 million per year would be more appropriate. The Government's programme provides for the authorisation of schemes of road-building from 1958–59 to 1961–62 costing £280 million. What the actual expenditure per year will be is not known. According to Mr. Watkinson the country's total expenditure on roads in 1957 was " well over £100 million." But such figures fall so far short of estimates made at the Conference that it is not at all surprising to find the Minister using all the arts of propaganda to try and convince the country that the Government's road plans are adequate. Dare we therefore hope that Mr. Watkinson and his Ministry are planning better things and that expenditure is inadequate at present not from lack of will but because there are inevitable delays in getting a really satisfactory programme under way ? Maybe road-building may prove to be like munitions production during the war, of which Sir Winston said something like this:—" In the first year nothing. In the second year very little. In the third year barely enough. In the fourth year all you want." At what rate will road construction be proceeding in 1962? Not impossibly it may be progressing at a rate much more satisfactory than at present.

INDUSTRIAL PEACE

A plea for more intensive research into industrial unrest has been put forward by Dr. E. P. Kelsall in the latest number of *Occupational Psychology*, the journal of the National Institute of Industrial Psychology. Dr. Kelsall, who is a management consultant, holds that it is not less important to co-operate on improving the contentment of people at work than to co-operate on improving their return for their labour. He says, in fact, that " if forecasts of considerable increases in living standards are correct, it may well be the more important problem." Dr. Kelsall admits that it may seem fanciful to think of employers and unions collaborating to support such research, but he urges that their joint sponsorship may be almost a prerequisite of success. It would also, he adds, strengthen collaboration on productivity, efficiency and mobility of labour. Dr. Kelsall has analysed, quite succinctly, what he describes as the " logical and psychological " components of industrial conflict. He also has something to say about the way in which union leaders tend to be at cross purposes with their members because of different influences and aims and the difficulty of adequate communication. The logic of a situation and the economic and political elements of it, Dr. Kelsall asserts, affect union officials more, while their members are influenced in their attitude by such things as poor supervision, monotonous work, noise in the factory, unsatisfactory housing and social deprivations. The official union reaction tends to be dominant in prosperous times and may show in rare, but bigger, and better organised strikes; the reaction of individual workers is more important in times of economic depression and may be expressed in frequent unofficial stoppages.

These, it would seem, are the kinds of matter that ought to be more fully investigated if the real roots of industrial conflict are to be discovered. We do not challenge Dr. Kelsall's claim that more intensive research along these lines " would pay off handsomely in money, let alone contentment." But we cannot help ruminating upon what really springs from the mass of data that has already been gathered, and is still being assembled, on almost every possible aspect of human relations in industry. It is more than likely that there is enough theory in existence now for a start, at any rate, to be made on such repairs as may be necessary to employer-employee relationships. On both sides of industry, we would say, the view is generally held that strikes are an anachronism ; they never satisfactorily settle a dispute. Yet every year, industry has to suffer disruption because of thousands of stoppages of work through disputes, even though the majority of them do not last more than a day or two. A co-operative approach by management and unions to attack unrest at its source and thus remove causes of strikes and other symptoms of discontent is one method advocated by Dr. Kelsall. It is not a new suggestion, but it is one which has not been whole-heartedly supported in recent years. We recall, for example, that the courts of inquiry which examined wage disputes in the engineering industry in 1954 and in 1957, recommended the setting up of " some joint body " which could periodically review the state of the industry in an atmosphere free from the tension often provoked by a dispute. A body of the kind could be of great assistance in promoting industrial harmony. There are bound to be occasions when differences between management and labour arise, but the achievement of co-operation and a full sense of responsibility would inevitably narrow conflicting issues and encourage their resolution by peaceful means. If the research already performed and that now advocated by

Dr. Kelsall can contribute anything to that end, it will not be wasted.

"FLAGS OF CONVENIENCE"

The United Nations Conference on the Law of the Sea, now sitting at Geneva, has no more important or more controversial subjects to discuss than the questions of the limit of territorial waters and of what is now generally known as "flags of convenience." Britain will have the support of twenty-seven other countries in pressing for the retention of the traditional 3-mile limit. But there are many other nations who are less concerned with the rights of belligerents in territorial waters than with peacetime considerations. There are demands, for example, for exclusive fishing rights over areas extending far beyond 3 miles from the coast—in some cases to a distance of 200 miles. In the view of the British Government the question of fishing rights and other peacetime requirements of that kind are best dealt with by Treaty between the countries concerned, on the lines of the Anglo-Soviet Treaty negotiated a year or two ago. But of more immediate importance to maritime nations engaged in overseas trade is the question of the registration of vessels in countries where there is no genuine link between the ship and the country of registration, the main objects of this kind of registration being, of course, to avoid taxation, high crew standards and consequent high operating costs. The Members of the Conference will have the full facts before them from a report recently prepared by the maritime transport committee of the Organisation for European Economic Co-operation, which strongly criticises the growth of the system of "flags of convenience."

In 1939 the total tonnage registered in the four countries, Panama, Liberia, Costa Rica and Honduras, amounted to only 3000 tons. By the end of the war the figure had increased to 700,000 tons and is now no less than 12,500,000 tons and still increasing rapidly. Four-fifths of the tonnage so registered belongs to owners of Greek and United States nationality and consists predominantly of tankers or tramps. In October, 1957, more than 18 per cent of the total tonnage and about 25 per cent of the total tanker tonnage under construction in the world's shipyards were being built for registration under the flags of these four countries. The International Law Commission gave much thought to this problem and recommended that the flag State should always be in a position to exercise effective jurisdiction and control over ships flying its flag. This cannot be done if the shipowner is not a citizen of that State and has no other connection with it than the formal one of registration. The commission went on to recommend that international and national legislation should be changed accordingly, but in view of the economic advantages and the consequent high profits of the system, it seems unlikely that a unanimous decision will be reached. The avoidance of taxation and relief from high crew standards result in much lower operating costs and enable these "flags of convenience" fleets to develop at a much faster rate than those of the genuine maritime countries. The British Government, by doubling the investment allowance a year ago, has gone some way to help our shipowners replace their ships. But with taxation at approximately 2s. on every ton of cargo carried it is becoming more and more difficult for British shipowners to compete against these tax-free countries in replacing their fleets from retained earnings with the cost of building a cargo liner now nearly five times as much as it was twenty years ago. Unless indeed some international agreement on the subject can be reached in the near future, a substantial portion of the sea transport of the world may well pass into the hands of the "flags of convenience" countries.

THE WEST LONDON MOTORWAY

Mr. Watkinson has just announced preliminary plans for a motorway in the western suburbs of London, serving London Airport and the motorway route to South Wales; details are given on page 479. The announcement is much more than ordinarily interesting. For it has long been realised that the construction of motorways in urban areas is the "hard core" of difficulty in the road programme. Without them, city centres will decay, and the motorways between towns would merit the description "pipes with their ends blocked." But equally their construction represents a surgical exercise of such severity that some opinion held that it would never be attempted. The West London route has been planned partly as an elevated road, so as to give the traffic facilities needed so desperately with the minimum of interference to existing buildings and amenities. It demonstrates that good engineering design can overcome many of the seemingly intractable problems of urban motor road construction. It also demonstrates that official policy is now alive to the urban road problem and is willing to seek an imaginative solution. That, in fact, is the more encouraging aspect of the announcement. We have consistently maintained that a basic network of motor roads serving greater and central London is an indispensable "skeleton" on which future planning needs to be based—indeed no satisfactory town planning is possible otherwise. So it can be hoped that the West London proposal will be the prototype of a new motorway system serving the metropolis. Its construction should, we urge, proceed as rapidly as possible so that information on its economic benefit can be gathered.

The Engineer—100 Years Ago (MARCH 26, 1858)

"A REVIVAL"

"The conservative principle is strong in human nature, especially in its maturer growths. Men do not like ever to be tossing on the restless waves of innovation. . . . We have been led into this train of thought by an announcement that a successful steam locomotive has been constructed for common roads. The construction of an engine for common roads seems to have been long given up by all moderate people as a hopeless task. And we have for the last ten years been so engrossed in the construction of railways, and have so generally and largely invested our money in them, that we have had neither time nor inclination to think about engines for common roads. Certainly, all the conservative engineers are dead against any such scheme, and leave it to the 'fast,' or rather to the foolish. Not so, however, Messrs. Adamson and Co., of Newton Moor, near Manchester, who have constructed and tested an engine for common roads, which is alleged after trial to work very satisfactorily. . . .

"The engine weighs 2 tons 16 cwt, is equal to a journey of seven or eight miles per hour, and may be driven at a much higher speed. The total length is 9ft 10in, this additional length affording space for the stoker and controller; the width is 5ft 4in. It is driven by a pair of wheels, 3ft 6in in diameter, and there is one wheel under the front end, which is under the direction of the controller, who guides it by turning a handle similar to a railway brake. There is a small cylinder on each side having 18in stroke, and the engine will work up to 16-horse power. The tyres of the wheels have a good breadth, so as to give ample bearing should the road be soft. . . . We can only add that we shall be very glad to see the new locomotive succeed, and we wish the 'controller' better luck than the last of his fraternity, who, we believe, ran his engine into a plate glass window instead of along the 'common road,' for which it was designed, but which in a sudden and uncontrollable freak it abandoned."

London Planetarium

No. II—(*Concluded from page 424, March 21*)

On March 19, the official opening took place in London of the first planetarium in Great Britain and the Commonwealth. In our issues of May 17 and 24, 1957, we reproduced a lecture given by Professor Dr. Walter Bauersfeld, of the firm of Carl Zeiss, German Federal Republic, before the Institution of Mechanical Engineers, in which the speaker described his invention of the projection planetarium nearly forty years ago, as well as the incidental invention of shell concrete. Since its first appearance the planetarium has developed into a universal instrument capable of reproducing, greatly speeded up, and with an accuracy and in a realistic manner which are truly extraordinary, those astronomical events, present, past or future, which can be observed with the naked eye. This article describes the projection planetarium, including its most modern developments, and in particular the installation which has now become available to the public.

Moon.—The moon's orbit in nature is inclined at an angle of 5 deg. 14 min to the ecliptic and undergoes an 18·6 year precession in a direction opposite to the moon's revolution round the earth, called the regression of the nodes. This is reproduced in the machine by mounting the projector assembly on a trunnion situated at the centre, which represents the position of the earth. The projector assembly is driven by two gear trains, both actuated by the planetary line shaft which engages with the claw coupling shown on the left in Fig. 5. The rear train rotates a forked lever which engages with a guide pin on the projector and operates the monthly revolutions. The front train rotates an inner collar on which an inclined ring is rotatably mounted which carries the projector rear support. On the latter slides a longitudinal guide rod, thereby causing the moon projector to revolve parallel to the ring, which is inclined to the ecliptic at the correct angle of 5 deg. 14 min. The collar is rotated once in 18·6 planetarium years and so gives rise to the correct precessional effect.

While earlier moon projectors produced the image of the moon's disc by means of a mirror made from an alloy of gold and silver, the most recent designs have aluminium-coated concave glass mirrors. The introduction of a stronger projection lamp and of coated lenses increased the available illumination four-fold and made it possible to show details of the moon's surface. This is achieved by blacking-in the dark spots on the mirror of one projector, leaving the other bright. The phases are produced by the rotation of a hemispherical cup round the mirror by means of subsidiary gearing. Fig. 10 shows one of the two moon projectors.

Sun.—The sun's mechanism is the simplest, comprising merely a central fixed pin about which the projector system rotates, while the other end is guided by a pin revolving on a wheel representing the earth's orbit and offset by twice the eccentricity. Much trouble has been taken to approximate the natural appearance of the sun by employing four projectors, two for the disc and two for the sun's halo. A fifth and smaller projector is for the zodiacal light, while two small rear-facing projectors are for showing the counter-glow or gegenschein.

As with all projectors, allowance must be made by a corresponding tilting adjustment for the fact that they are situated off the centre of the machine and hence off the centre of the planetarium dome.

Saturn.—This mechanism is constructed on similar lines to that of Jupiter, and is housed next to the sun projector in the northern planetary machine.

Fixed Stars.—The planetarium shows some 8900 fixed stars, i.e. all above magnitude 5·8. These are projected from thirty-two lanterns mounted on the large spherical carriers seen in Fig. 1 (*ante*), illumination being by two 1000W lamps at the centre of the carriers. The spheres were formerly produced by hydraulically expanding in several stages, with inter-annealing, a pair of spun brass pans brazed together along the edge. They are now made from sections assembled by brazing. No extreme precision is required, as the star projectors are adjusted *in situ*.

Each projector consists of an aspherical condenser and a F/4·5 "Tessar" of 12cm focal length. Immediately behind the condenser is the star plate which, in the latest models, consists of a layer of chromium perforated by a photochemical process. The holes vary in diameter between 0·028mm and 0·75mm in accordance with the required brightness. They were previously punched by hand in 0·015mm thick copper foil with sixty-five different sizes of punch. The reason for the change was that some of the copper plates were found to corrode after long periods, causing the holes to close up.

For the purpose of representation by flat lantern slides, the celestial sphere is imagined to be replaced by an icosahedron with the corners cut off, equivalent to twenty hexagons and twelve pentagons, or thirty-two fields altogether. Provision is made when photo-

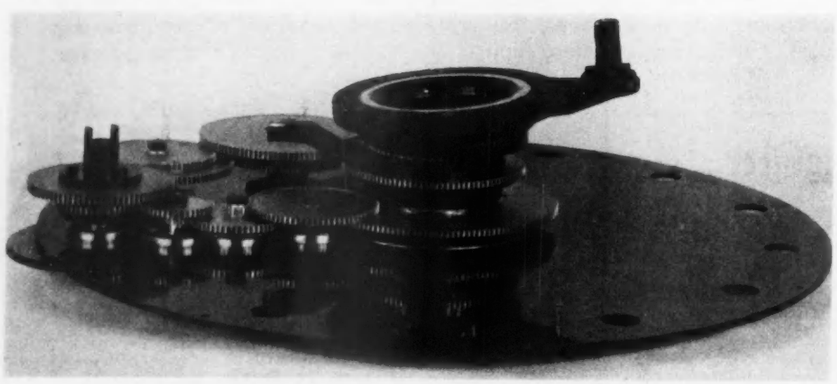


Fig. 5—Gear trains of moon mechanism. The drive is from the planetary lineshaft (not shown) engaging with the claw coupling seen on the left. The twin projector rotates about a central axis representing the position of the earth. This monthly revolution is imparted by the rear gear train driving the forked arm, here pointing to the left. The correct inclination of the orbit is brought about by the fact that the sliding bearing of the projector guide rod sits on an inclined rotatable ring. The ring takes the form of a ball bearing, the plane of whose inner race is rotated by the front gear train, thereby giving the 18·6 year regression of the nodes

Fig. 6—Internal view of southern " ruff," showing optical systems for bright stars. The two projection lamps are positioned diametrally opposite each other. Each is equipped with a series of image pinholes. The stars are projected by individual long-focus lenses over systems of mirrors and right-angle prisms

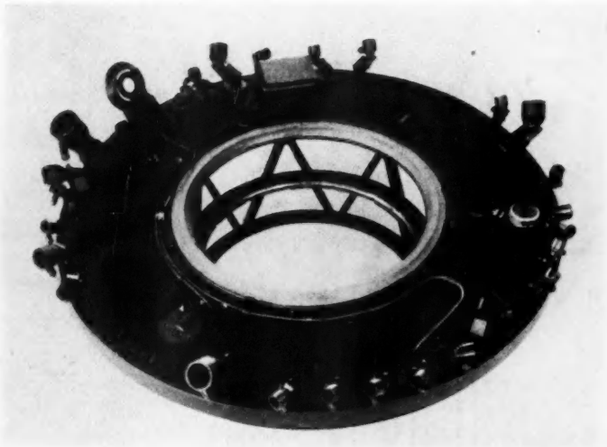


Fig. 7—Outside view of southern " ruff," showing the projection lenses equipped with gravity operated occulting devices for suppressing any light below the horizon. At the top is the transformer for the low-voltage supply, to the left of it the bracket for one of the two Milky Way projectors

graphing the star maps to introduce a corrective distortion.

For aligning the projectors, the plates are perforated to mark the corners ; these lines are subsequently painted over. Since it is undesirable to have the projectors shine into the audience's eyes, all rays below the horizon are cut off by occulting devices constructed on the lines of " sleeping doll's eyes."

Special Projectors

In order to represent the brightest stars without having to increase their diameter unduly, it was decided to increase the number of special projectors. The only objects for which these had previously been provided were Sirus, the Milky Way, and three variable stars. In the present instrument, in addition, all forty-two stars down to magnitude 2 are produced by special projectors. These are fitted on and inside the " ruffs " just below the fixed star carriers. Our illustration (Fig. 6) shows how the star images are obtained from two lanterns situated inside each ruff at diametrally opposite ends. The lanterns are provided with apertures of the correct size , the images of which are projected by a system of mirrors, prisms and lenses. In Fig. 7 may be seen the outside of the ruff with the prisms which allow final adjustment of position to be made ; all the projectors are fitted with individual occulting devices.

On the ruffs are also carried the projectors for the Milky Way, one each for its northern and southern branch (not shown in Fig. 7). The image of the Milky Way is produced by projecting a simple shadowgraph from a cylindrical negative, behind which is placed a 10W lamp. The negative is made from a drawing which, in turn, is based upon photometric measurements. Care has to be taken when shading-in the drawing to use random patterns in order to avoid diffraction effects.

Situated in the southern ruff is the parallax projector for Sirius (Fig. 8). As has been explained, Sirius was selected on account of its brightness and because of the magnitude of its parallax. The combined parallax and aberration ellipse is produced by a corresponding elliptical displacement of the front lens of the optical system, by means of the geared motor drive shown.

Individual drives have also been introduced for the variables Mira Ceti, Delta Cephei and Algol, so that these stars are now changing their brightness in a much more gradual fashion than was possible with hand control.

In the smaller spheres at the ends of the instrument are housed the constellation projectors equipped with F/4·5 " Tessars " of 3cm focal length, as well as graduated dials allowing the precessional rotation to be measured against a projected mark. Similar spheres fitted in other places on the instrument and on the frame, are used for the equatorial grid reference and the meridian (see Fig. 1).

It is not possible here to do more than outline some of the special demonstrations which may be given with the planetarium projector or by using ancillary instruments.

Mean Sun and Nautical Triangle.—Equipment for demonstrating the mean sun is fitted to a lattice ring driven in the plane of the celestial equator by the annual movement (Fig. 1). A small lantern carried on this ring projects by means of a cylindrical lens, a portion of an hour circle extending 23½ deg. north and south of the celestial equator. At the intersection with the equator the mean sun is represented by a small circle of light. Comparison of its position with that of the true sun by means of the grid is readily possible and directly gives the equation of time.

The three sides of the Nautical Triangle are obtained by projecting the meridian and hour circle, the latter being at right angle to the lattice ring and produced by a special projector fixed to it which also produces the third side, zenith-star, by means of a gravity-controlled projection device.

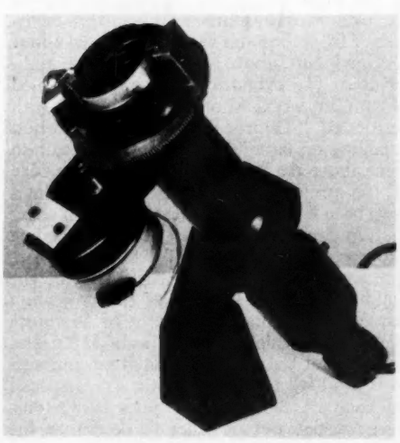


Fig. 8—Sirius parallax and aberration projector. The small motor drives a pair of sliding lenses situated in front of the objective, thus moving the projected image in an elliptical orbit

Solar System Projector.—The effect of viewing our solar system broadside-on from a distance of 1·7 Saturn radii is obtained by means of the solar system projector. This comprises an assembly of two parallel tubes, one of which contains a system similar to a Newtonian reflecting telescope. This projects an image of the sun from a 30W filament lamp. The other tube contains a similar 30W lamp situated in the centre near the bottom. By means of lenses and prisms, six light spots representing the planets Mercury to Saturn are thrown on the ceiling. The light beams are deflected by prisms to a greater or lesser extent to give the correct size of the orbits. The final prisms are rotated by motor-driven gears, so that the light spots travel around the stationary sun at the correct relative speeds.

The Planetarium Building

An important part in the performance of a planetarium is played by the building, its layout, acoustic properties, and air-conditioning arrangements. The London Planetarium is situated a few steps away from Baker Street station, and much care had to be taken to suppress the transmission of vibrations from the Metropolitan Line, which runs underneath Marylebone Road with approximately 30ft between the edge of the building and the crown of the tunnel some 6ft below the road level. Vibration is heavy and very noticeable in the basement of Madame Tussaud's, 150ft from the road, and the condition is made worse by the fact that the trains have to slow down at the points just outside Baker Street station, causing heavy reverberation.

It was decided to eliminate vibration as far as possible by resting the dome on a massive floor slab supported by columns. Fig. 9 represents a cross-sectional elevation of the building, which clearly shows this mode of construction.

The building rests on twelve groups of four 45ft piles, with the groups equally spaced on a 58ft 6in diameter pitch circle, together with six piles equally spaced on a 20ft 6in diameter circle. The outer groups of piles are each capped, about 10ft below ground level, by 2ft thick concrete, and

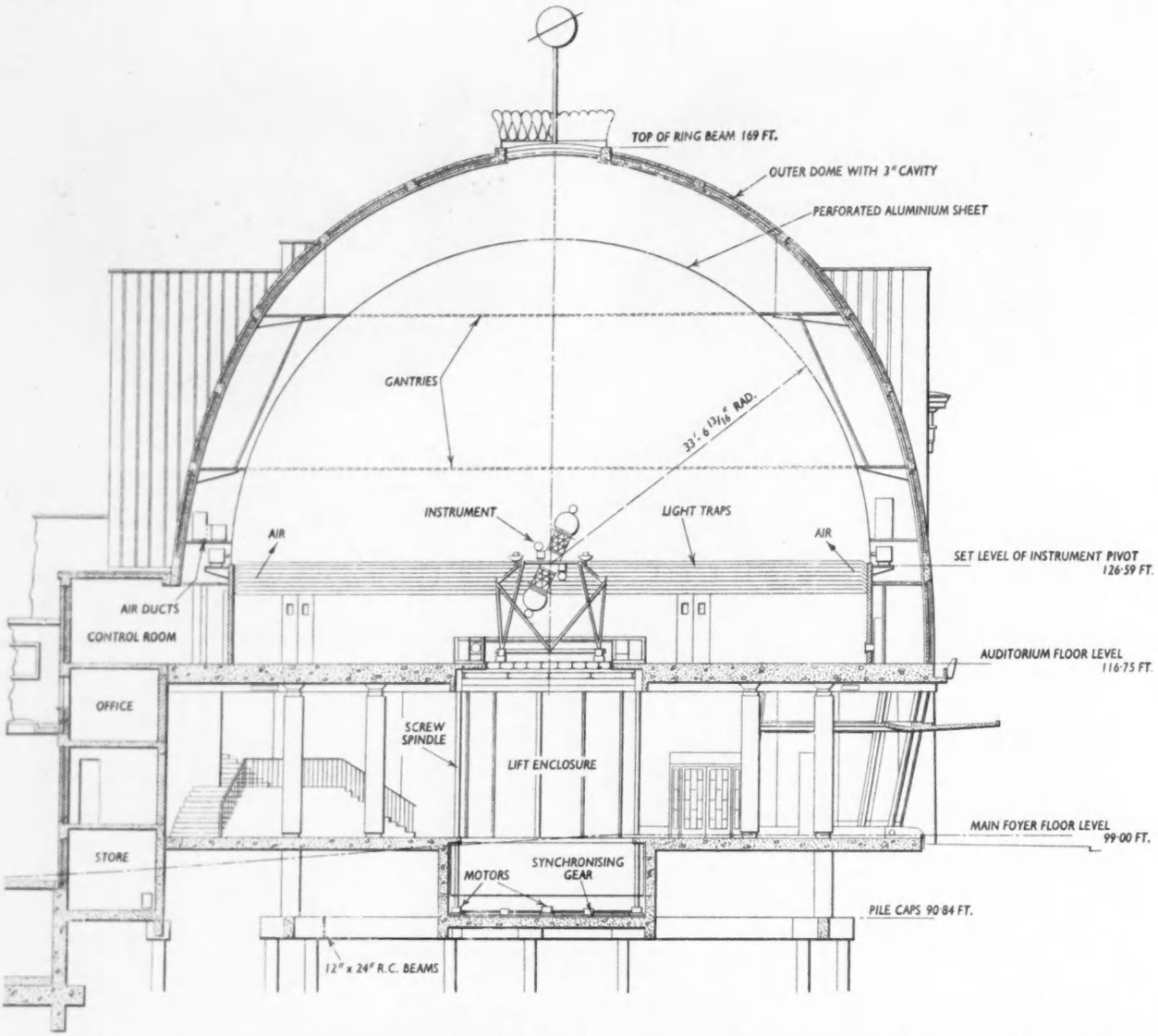


Fig. 9—Sectional elevation of the planetarium building. The auditorium can seat 547 spectators. When not in use the planetarium instrument is lowered by lift to the foyer, where it can be viewed in its glass enclosure

joined together by reinforced concrete beams 12in wide by 24in deep, while the six inner piles are provided with 12in thick caps. The drum-shaped well of the instrument lift, measuring internally about 20ft in diameter and having a 12in thick bottom and walls, rests on the inner circle of piles, and it and the pile caps of the outer group are connected by 12in by 24in deep concrete beams.

The 15in thick reinforced ground floor slab, which measures 77ft 9in in diameter, is cast integral with the instrument well, and elsewhere rests on 18in diameter reinforced concrete columns which rise from the centres of the outer pile caps and continue upwards to support the main slab at first floor level.

This 2ft thick slab has a diameter of 80ft and its upper surface is 17ft 9in above the main foyer at ground level. In the centre a hole is provided for the platform of the instrument lift. On the circumference rests the double shell of the outer dome.

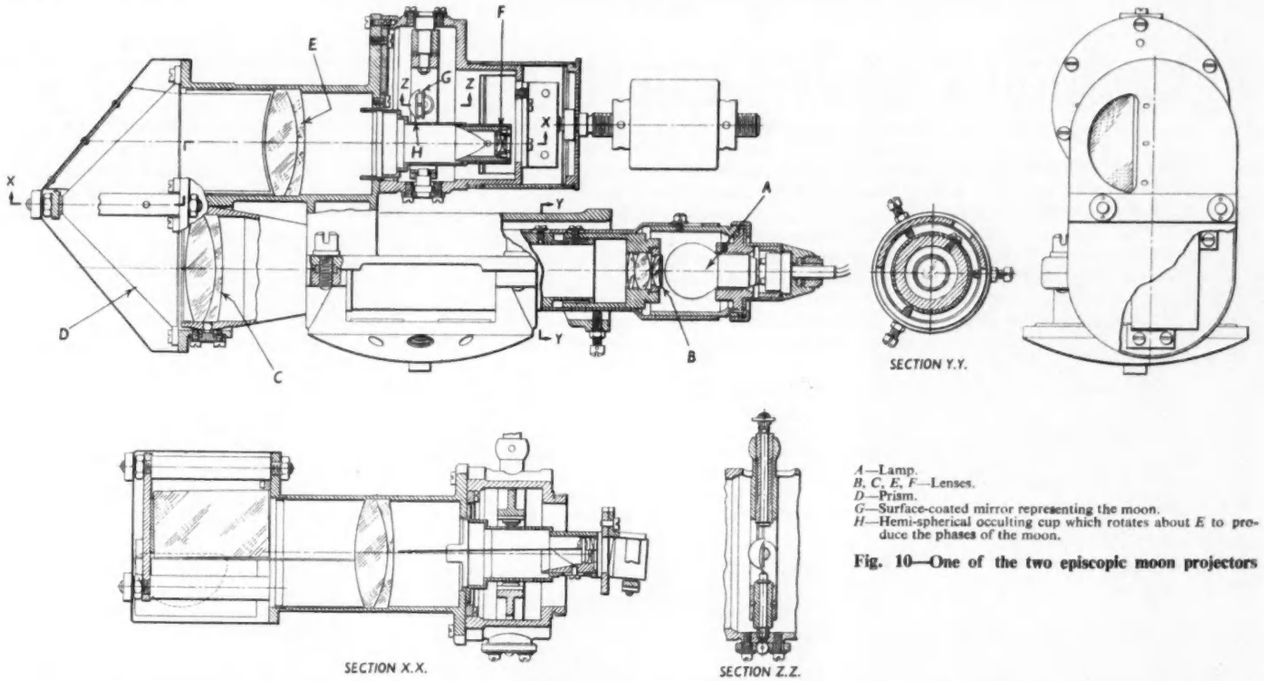
As may be seen from our illustration, the dome is built up from vibrated precast reinforced concrete panels, 3in thick, with a 3in cavity between the inner and outer shell. This 9in thick assembly is held together by precast vertical beams and tee-section horizontal rings cast *in situ*, each 9in thick and 12in across its shorter side. Altogether 1432 panels are used.

The outer wall of the auditorium is formed by a 10ft 3in high cylindrical steel framework about 67ft in diameter, which is surmounted by the projection dome. Inside the cupola are two circular aluminium gantries cantilevered from the outer shell and situated about 20ft and 36ft above the level of the auditorium. The cylindrical framework is filled in with 2in wood wool slabs and faced with perforated "Gyproc" slabs and hardwood panelling on battens. For the last 3ft or so from above the level of the doors to the edge of the projection dome, aluminium plates have been fitted to the wall at 45 deg. in order to trap any light reflected from the ceiling and give the impression of a black horizon. The intersection of the vertical axis of the building with the horizon of the projection dome is, of course, the centre of curvature of the dome which has a radius of 33ft $6\frac{13}{16}$in.

The total weight of the building amounts to some 1740 tons, so that the average load on each of the fifty-four piles is 32 tons. Tests carried out in order to determine the capacity showed that at twice the required load a movement of less than $\frac{1}{32}$in occurred with full recovery on unloading. Vibration measurements carried out by the Building Research Station, which throughout acted in a consulting capacity, showed that on the ground floor the transmitted amplitude was less than 2×10^{-7}in, while on the first floor half this value was obtained. In order to reduce drumming, the whole of the site under the self-supporting ground floor down to the pile caps was filled with loose rubble. Lateral transmission of vibrations is avoided by not allowing any neighbouring structures to abut directly. The flexible joints which have been fitted also give the necessary freedom for thermal expansion.

The requirements which were laid down for the acoustic design of the dome stipulated that reduction in noise as compared with the outside should be better than 25 decibels. With early planetaria it had been found that reverberation from the inner dome, if this was in the form of a solid surface, was quite unbearable. It is for this reason that a perforated surface is used, with sound-absorbing material fastened to the outer shell behind. On the other hand, sufficient reverberation must be left to give a plastic quality to music, and, of course, the surface must appear solid to the projection. In consultation with the firm of Carl Zeiss it was decided to have an area ratio of holes : solid of 10 per cent.

Considerations of strength and stability led to the adoption for the inner dome of



A—Lamp.
B, C, E, F—Lenses.
D—Prism.
G—Surface-coated mirror representing the moon.
H—Hemi-spherical occulting cup which rotates about *E* to produce the phases of the moon.

Fig. 10—One of the two episcopic moon projectors

solution-treated, half-hard aluminium alloy of 16 S.W.G. The sheet was perforated with twenty holes of 0·081in diameter, per square inch. The panels are butt-jointed and screwed to sixteen aluminium ribs which are held in position by two tubular aluminium tension rings and bolted to the steel substructure at the bottom. The holes in the sheet also help to take up expansion and contraction and so reduce any tendency to buckle. If lights are switched on behind the perforated dome it appears to become transparent, thus making possible the presentation of tableaux and similar effects. Star haze on the horizon is absorbed by the light traps mentioned. The actual line of the horizon is formed by a 2ft deep cut-out representing the London skyline. Behind are three rings of thyratron-controlled cold cathode tubes coloured red, green and blue. By varying the tone and intensity of the light from these tubes it is possible to simulate sunrise and sunset.

On the outside the concrete dome is insulated by a 1in layer of granulated cork in a bituminous bedding, applied between 2in by 1in horizontal wooden battens spaced 12in apart. At the crown the insulation is increased to 2in. The whole was covered with bituminous felt and finally dressed over with 23 S.W.G. copper sheet. This insulation will help to equalise the temperature of the concrete and prevent unequal expansion due to the varying incidence of sunlight.

The air space between the walls is packed with glass silk, and on the inside surface a 4in thick acoustic blanket of 7 lb per cubic foot mineral wool is fixed and held in position by fireproof Hessian. This is covered with chicken wire fastened to $\frac{3}{16}$in diameter steel rods let into the concrete at 1ft 6in centres. The use of these rods constitutes another strong argument in favour of good thermal insulation of the dome, for without it, the rods would get chilled in cold weather by conduction, which would cause a constant drip of condensing moisture from the 2500 tips.

It is important to have adequate air-conditioning, not only for the comfort of the audience but also to obtain a clean atmosphere free from any Tyndall effect which would completely spoil the illusion of seeing the actual night-sky. For this reason the air changes are twice what is required by L.C.C. regulations. In order to minimise noise the air speed is reduced to about half the usually accepted value, by installing double-size ducting. A 42-cell air filter, capable of stopping all particles over one-five thousandth of an inch in diameter, has been fitted. This filter requires renewal every three months. Space is available for installing an electrostatic filter later, should this be required. Fan noise is minimised by fitting a silencer immediately behind the fan. This is of the design used for jet engines and is 12ft by 8ft high by 5ft wide. A slight excess pressure is always maintained in the building so as to exclude dust.

As there is a tendency for rock wool to form a fine dust, which would be most undesirable, special steps were taken to cover the Hessian over with linen so as to stop the dust getting into the atmosphere. All textiles have been specially fire-proofed.

The internal temperature is controlled at 65 deg. Fah. with an outside temperature of about 30 deg. Fah. Boosters capable of raising this to 73 deg. Fah. are installed.

The planetarium instrument is situated at the centre of the hall on a platform which can be lowered into the foyer where the public can inspect the instrument behind glass between performances. The lift has a capacity of 5 tons and a travel of 18ft. It is operated by four 6in diameter screw spindles each driven by its own geared motor, but all synchronised by virtue of being mechanically connected through bevel gearing and shafts to a common central bevel wheel. The lift, which was designed by Knight Construction, Ltd, London, S.W.4. is equipped with limit switches giving an end position accurate to within $\pm 0{\cdot}005$in. The design is characterised by the absence of pulleys, wire ropes and similar components which would interfere with the presentation of the instrument in the foyer. When the platform is raised the electrical connections are automatically made by means of two sets of male and female knife contacts. It is not possible to traverse the instrument in order to imitate the effect of the proper motion of our solar system.

The auditorium can accommodate 547 spectators. The planetarium instrument is controlled from a U-shaped desk near the wall. On the central portion of the desk the planetarium controls are arranged, while the right-hand part houses an array of switches for the auditorium lighting, including the coloured fluorescent tubes for the horizon lighting. To this will be added at some future date the lighting of tableaux and models which are to be placed behind the projection dome. The control desk is also connected to an internal system of telephones and warning lights. Music and speech can be reproduced from magnetic tapes and broadcast over loudspeakers. The sound controls are housed in the left part of the desk, on which is also mounted the solar system projector. A control room adjoining the auditorium houses the main switchboard, the controls for the instrument lift and lighting, and those of the ventilation fans.

The building was designed by Mr. George Watt, A.R.I.B.A., with G. W. Kirkland, M.B.E., M.I.Struct.E, as consulting engineer. The main contractor was A. J. Wait and Co., Ltd.

Correction

In No. I of this article, two lines were omitted from page 423. The second paragraph to commence in the second column should open with the sentence : "Superimposed on the daily and annual movement is the precession of the earth's axis which, from the earth, appears as the precession of the equinoxes, the points in which the celestial equator intersects with the ecliptic."

Heavy Die-Handling Truck.—A new truck with an elevating roller platform is being marketed in capacities of 500 lb, 1100 lb and 2200 lb by G. Hunter (London), Ltd., 80, Fenchurch Street, London, E.C.3, for handling heavy dies in press shops. The platform can be swung through a full circle on the elevating arm and moved sideways up to 6in on either side of the arm. The low chassis of the truck is carried on rubber-tyred wheels, the two front ones of which are of castor design so that the truck can be easily manœuvred in confined spaces. The pump of the hydraulic system used for elevating the platform is operated by a foot lever from either side of the truck, and a self-locking release valve is pedal controlled. At its lowest setting the platform is 9½in above floor level and at its highest 27in.

Electrical Engineers Exhibition

No. I

More than 400 exhibitors are taking part in the Electrical Engineers Exhibition which was opened at Earls Court on Tuesday last by the parliamentary secretary to the Board of Trade. A special display of electrical equipment in hospitals, including a completely fitted operating theatre is to be seen on the ground floor. Much space is devoted to education, training and careers in the electrical industry. The other exhibits cover most aspects of electrical engineering and include generators, motors and control gear, transformers, wires and cables, lighting fittings, domestic appliances and instruments. Some of the new products are described here. The exhibition closes tomorrow at 7 p.m.

Lancashire Dynamo Group

AMONG the new developments shown by Lancashire Dynamo Nevelin, Ltd., St. Stephen's House, Victoria Embankment, London S.W.1, is a direct-to-mains "Varionic" variable-speed drive which incorporates a steel-tube "Nevitron" single-anode rectifier. This tube is more robust than the single-anode glass bulb rectifier which it replaces, and can be made to handle larger outputs.

In the direct-to-mains "Varionic" drive no rectifier transformer is required. Six "Nevitron" grid-controlled pool-cathode tubes are connected in a bridge to provide six-phase rectification, supplying smoothly controlled d.c. power to the variable speed motor. Standard Nevelin static control gear is used, as in conventional multi-anode rectifier "Varionic" drives, to enable close speed regulation to be obtained over wide changes of load and speed. The "Nevitron" tube is a single-anode continuously excited pumpless mercury-arc rectifier which is available in 50A and 100A ratings. A typical direct-to-mains "Varionic" drive is shown in Fig. 1.

Another new development in the control of electrical machines is embodied in the "Transidyne" which is a "transistorised" Ward-Leonard variable-speed drive exhibited by Lancashire Dynamo Electronic Products, Ltd. The "Transidyne" equipment is packaged, as shown in Fig. 2, for convenience in installation and application. It incorporates a Ward-Leonard motor-generator set to provide regenerative braking and stored energy for rapid acceleration without imposing transient loads on the supply system. The motor-generator set is mounted on anti-vibration pads. A blower on the motor-generator set provides filtered air circulation for cooling the cubicle. The circuits which provide "closed-loop" servo-control of speed take the form of standardised printed circuits on plug-in boards. The equipment exhibited is fitted with a transparent side panel to show the interior layout, as illustrated.

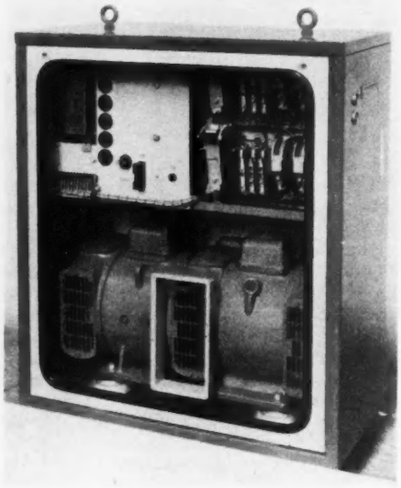


Fig. 2—Exhibition model of "Transidyne" variable-speed drive with transparent side panel showing interior construction, including anti-vibration mounted motor-generator set—Lancashire Dynamo Electronic Products

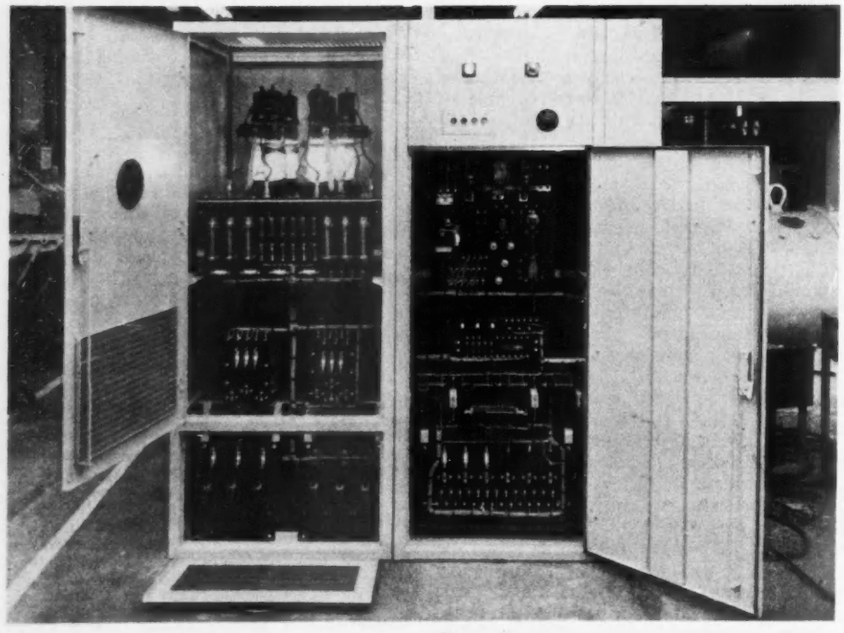


Fig. 1—Direct-to-mains "Varionic" control system for motor drive—Lancashire Dynamo Nevelin

Among the new products of Lancashire Dynamo and Crypto, Ltd., to be seen on the same stand is a small forced-ventilated torque motor which has an output of about 50 lb-in at any speed from 0 to 900 r.p.m., being suitable for use as a continuous spring in reeling and similar drives. A range of such motors, which can run at any speed (up to the specified maximum) or can operate continuously stalled, is available. The company is also showing a fully flameproof Buxton-certified motor of 3 h.p., equipped with a flameproof electromechanical 6in brake.

Rawlplug Company, Ltd.

A new portable electric drilling machine, which has been developed by the Rawlplug Company, Ltd., of Cromwell Road, London, S.W.7, combines a vibratory action with a fast rotary movement for drilling holes in concrete. It consists of a portable electric drill incorporating a gearbox and to it there is clamped a vibrating head. A knurled ring on this head can be turned to selector positions giving the drill a rotary movement only, rotation combined with light rapid vibration, or rotation combined with heavy slow vibration. The normal drill chuck speed is 940 r.p.m. and the selection of the force and speed of the vibratory motion can be made in accordance with the class of material being drilled.

The maker states that these "Vibroto" drilling machines are suitable for use with special hard tipped drills which have a negative angle at the cutting edges. Holes for "Rawlplug" sizes from No. 6 to No. 20 can be drilled with the machine. The drills have a consumption of 310W and are suitable for 230/250V supplies; they weigh just under 10 lb and have an overall length of 18½in.

Ferguson Pailin, Ltd.

On exhibit for the first time is an example of the "BVC" switchgear made by Ferguson Pailin, Ltd., Higher Openshaw, Manchester, 11. This equipment has been designed to comply with the British Electricity Board's Specification S.2 (1955) for substation switchgear. It is of fabricated unit construction, being designed to be capable of being extended on either side in connection with switch units (of similar design or otherwise). Ample accommodation is provided for instruments and meters and, when necessary, an additional instrument panel can be fitted above the standard built-in panel. Safety shutters can be locked independently and incorporate interlocks to comply with the specified earthing requirements. All small wiring circuits are automatically broken by vertically mounted plugs and sockets which disengage as the circuit-breaker is lowered to the isolated position. Alternative jumper connections are provided for general testing or for use when the circuit-breaker is in the "earthing" position. The voltage transformer is connected in the protected zone. The time limit fuses are mounted inside the instrument panel. In other respects this switch unit is

similar to the company's existing "BV" switchgear.

Another equipment exhibited for the first time is the "ASB37, Form B," 3·3kV, 250MVA, 1600A air-break, single busbar, switch unit (Fig. 3). It is designed for the control of generating station auxiliaries and of heavier industrial plant. It incorporates

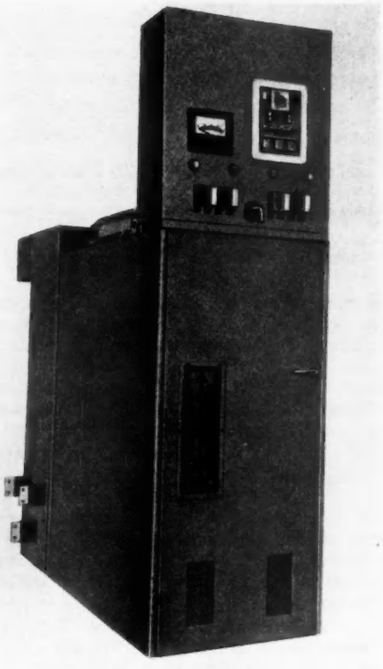


Fig. 3—"ASB37, Form B," 3·3kV, air-break single busbar switch unit—Ferguson Pailin

a number of innovations, including earthing on either feeder or busbar side, an operation which can be carried out equally easily without moving the truck within its housing, or removing or adding any current-carrying parts; a mechanically-driven mimic diagram shows the circuit state. The switchgear is equipped with arc chutes, a special arrangement of contact operating rods, a single toggle-type operating mechanism, heavy-duty main contacts, special high-pressure self-aligning isolating contacts, improved piston-type dashpots, and positive interlocking and simplified wiring arrangements. Care has been taken to keep the unit as small as is consistent with the flexibility of the arrangement of the gear, to reduce the maintenance necessary and to provide simple access to all components which may require attention or replacement. A flush front door keeps out dust or vermin and gives the unit an appearance in keeping with modern design trends.

Arthur Lyon and Co. (Engineers), Ltd.

A new range ("E.S.") of small self-exciting self-regulating alternators is being shown by Arthur Lyon and Co. (Engineers), Ltd., 6, Carlos Place, Grosvenor Square, London, W.1. These machines are intended for single-phase unity-power-factor loads in applications where the voltage regulation requirements are not particularly stringent.

The alternator is a revolving-armature machine in a screen protected, drip-proof enclosure, fitted with ball bearings. Field excitation is derived from two sources: a separate d.c. armature winding provides the no-load excitation and an auxiliary field winding is fed from the secondary winding of a current transformer, through a rectifier, to provide the additional excitation required on load.

Load regulation figures given by the maker are, at unity power factor $\pm 2\frac{1}{2}$ per cent, including an engine speed variation in accordance with B.S. 649, and, at 0·8 power factor, about $\pm 7\frac{1}{2}$ per cent.

The alternators are built and rated in accordance with BS. 2613/57 for class-A-insulated machines. They are available with standard foot mounting, end brackets and shaft extension, or with various flanges suitable for direct mounting on to certain diesel engines. They are also available in some instances as single bearing machines for direct connection on to the flywheel housings of certain air cooled diesel engines, in this instance the engine fan being utilised to provide the alternator cooling. Tropical impregnation is standard. The number of d.c. brushes used is a minimum and the direction of rotation can be reversed simply by interchanging the d.c. brush leads.

The "E.S." single-phase alternators are at present being manufactured with outputs of 3kVA to 11·5kVA, 50 c/s, 1500 r.p.m. and 3kVA to 12·5kVA, 60 c/s at 1800 r.p.m.

Johnson and Phillips, Ltd.

A new ring-main unit (Figs. 4-6), recently introduced, will be shown by Johnson and Phillips, Ltd., Charlton, London, S.E.7. A point of special interest is that the manual spring-operated mechanisms are designed to provide rapid opening and closing irrespective of any variation in the speed of the manual operation.

The "NX" ring-main unit consists of a standard J. and P. metal-clad oil circuit-breaker with two wing oil switches assembled in one common structure designed for situations where space is limited. The unit has a 400A normal current rating with oil switches rated at 250MVA at 11kV. Either plain-break or arc-controlled oil circuit-breakers can be fitted according to the service required. The oil switch sections have been tested and certified to B.S. 2631 (K.E.M.A. Certificate No. 7810 : 1957) and the circuit-

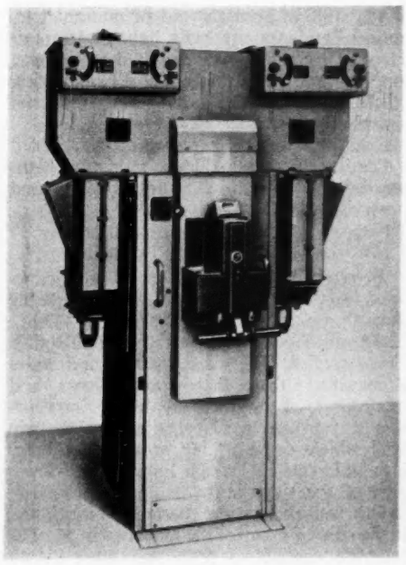


Fig. 4—The NX ring main is fitted with two manual-spring-operated switches for tapping a ring main. Normal current rating is 400A with oil switches rated at 250MVA at 11kV. Plain-break or arc-control circuit breaker can be fitted—Johnson and Phillips

breakers are certified to B.S. 116. The busbars and oil switches are assembled into one structure, which is non-extensible. The busbars and associated spouts are compound insulated whilst the oil switches are in oil-filled chambers.

Control of the "tee-off" circuit is by a standard J. and P. metal-clad oil circuit-breaker of the plain-break ("TDB") or arc-

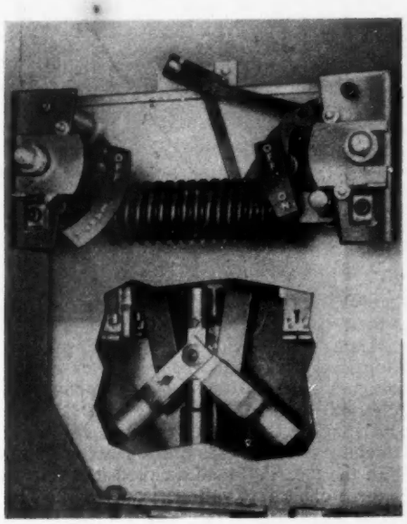
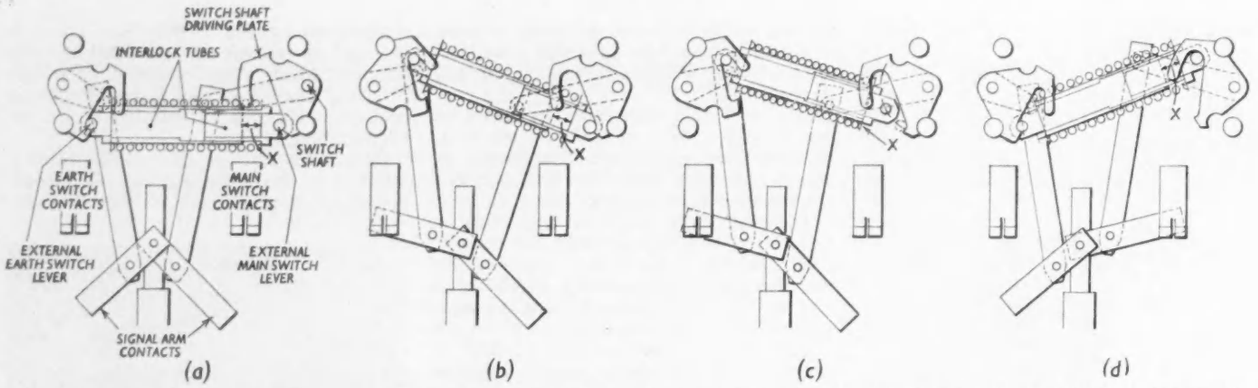


Fig. 5—Manual-spring-operated mechanism showing signal arm type "main" and "earth" switch blades, both in the "off" position—Johnson and Phillips

control ("TSB") designs, which are available for the following breaking capacity ratings:—Plain-break, 150MVA at 6·6kV or 150MVA at 11kV; arc-control, 250MVA at 11kV. Either breaker can be fitted with operating mechanisms of the manual, spring-operated manual, spring-operated power, or solenoid operated power types. A full complement of interlocks is fitted. A point of particular interest is the design of the switches, which have manual spring-operated mechanisms, which ensure rapid opening.

The operation of the two wing oil switch is explained by the diagrams (Fig. 6). Each switch contains a separate system of switch blades for "main" and "earth" connections. They are signal arm blades and both "main" and "earth" blades are hinged to a common cable box terminal. The individual blades are operated by separate shafts and insulating links, but one common spring is employed for the rotation of either shaft. This spring is provided with a "core" of tubes which joins the external levers of the "main" and "earth" switches and is so arranged that a foolproof interlock permits both "main" and "earth" blades of the switch to be open together, but only one or the other to be closed at one time.

To open or close the switch the spring is charged by means of a removable handle which the operator places over the switch shaft and the associated external lever and turns through approximately 45 deg. The external lever will pass over-centre, and then, driven by the spring, will pick up the switch shaft driving plate and rotate it smartly, thus closing or opening the switch. The mechanism is designed to give constant torque to the switch-actuating shaft, irrespective of the speed at which the operator charges the stroke and, after initial compression, the spring takes the action of the switch completely out of the operator's hands. The opening or closing of the earth blades is done



(*a*) Oil switch with both "earth" and "main" switch open. Note the space *X* between the two parts of the spring's core. This allows either "earth" or "main" switch to be closed on to its contacts, but will not permit both to be closed at the same time.
(*b*) "Earth" switch closed. Note the space *X* between the two parts of the spring's core.
(*c*) With "earth" switch closed an attempt has been made to close the "main" switch. The core ends have butted together and *X* has disappeared, thus preventing movement of the "main" switch.
(*d*) "Main" switch closed. Note the space *X* between the two parts of the spring's core.

Fig. 6—Diagrams of operating mechanism of oil switch of the NX ring main unit—Johnson and Phillips

similarly by applying the operating handle to the external lever on the earth switch.

Means are provided for inserting cable testing plugs through the top cover of the unit, but access to the test orifices can only be made with the "earth" blades closed—which means the "main" blades of the oil switch must be open, as previously explained. With the "earth" blades closed it is safe to connect cable test voltage leads to the test plugs and to open the "earth" just before applying the test voltage. Opening of the "earth" blades automatically traps the test plugs. These plugs cannot then be withdrawn from the test orifices until the "earth" blades of the oil switch are returned to the closed position.

An alternative arrangement of built-in test terminals can be supplied, if required. In this the "earth" connection is an integral part of the test terminal cover, which cannot be opened until the "earth" blades are closed. Conversely, the "earth" blades cannot be opened when the cover is in the open position. The "earth" blades having been closed and the cover removed, cable test voltage leads can then be attached to the terminals. When the test cover is re-closed an integral earth strip bridges the tops of the test terminals and the earth is automatically restored.

The "NX" unit is fitted with the following interlocks in addition to those normally fitted to the circuit-breaker. It is impossible for the "earth" blades of the oil switch to be closed whilst the "main" blades are in the closed position—and vice versa. Both switch blades can be in the "open" position. The test orifice cover cannot be opened unless the "main" switch blades are open and, conversely, the "main" switch blades cannot be closed when this cover is open. The test plugs cannot be inserted until the "earth" blades of the switch are closed and subsequent opening of the "earth" switch blades for testing the cable, traps the plugs so that they cannot be removed. Withdrawal of the plugs can only be effected after the "earth" switch blades are re-closed.

Means are provided for padlocking the test cover to prevent unauthorised opening, and for locking the oil switches in their respective "open" or "closed" positions. Auxiliary switches can be provided on the rear ends of the "main" switch shafts to facilitate protection in certain system designs.

The unit is provided with standard J. and P. cable boxes and three identical boxes are used for the oil switch cable connections and the "tee-off" cable. The boxes have three gland positions to facilitate cable entry from any direction. Epoxy resin bushings are used in the oil switches except for the isolating spouts which are insulated with porcelain. The oil circuit-breaker bushings are either paper or porcelain insulated according to the MVA rating.

Siemens Edison Swan, Ltd.

A new telephone hand-set, the first of its kind to incorporate printed circuits, is being shown by Siemens Edison Swan, Ltd., 155, Charing Cross Road, London, W.C.2. It has been specially styled and is moulded in high-impact-resisting plastics in various colours. The instrument is known as the Siemens Ediswan "Centenary Neophone." The hand-set weighs only 7 oz and it incorporates a new ring-type receiver, for better speech reproduction, and a special hygienic mouthpiece.

The case has been specially designed to exclude dust and insects and the introduction of the printed wiring circuit in place of the normal multiple wiring greatly enhances reliability and ease of servicing, the whole assembly being easily taken apart and reassembled with the aid of a screw-driver.

Another interesting exhibit is the audio-frequency staff-location system which provides personal paging of individual members of the staff without the aid of internal telephones, loudspeakers, bells, lights, buzzers or wires. Originally developed for hospital use, this equipment is equally useful in factories, offices, departmental stores, and industrial organisations.

Exhibits from the electronic control and indication division include a miniature high-speed indicator and a remote control and supervisory system.

Crompton Parkinson

A recently developed range of heavy-duty fractional horsepower motors is being shown by Crompton Parkinson, Ltd., Crompton House, Aldwych, London, W.C.2. These (series "T") are smaller and more streamlined than their predecessors and incorporate a number of design improvements. Symmetrical ventilation by twin fans which draw in air around the bearings and expel it through holes in the lower part of the shell, cause the temperature rise to be well below the permitted maximum in the case of many of the motor ratings. The long-life centrifugal gear and open circuit switch in these new machines are designed to function quietly within close speed tolerances irrespective of the load inertia and in dusty atmospheres. A small and spill-proof oil well carries a proportionally larger amount of oil than before and is supplied with sufficient oil for two years of running at normal ambient temperatures and hours of operation.

The bearings of the series "T" motor have been developed from the established "Marathon Mark III" bearings; at present the motor is only available with sleeve bearings.

Newman Industries, Ltd.

A new design of single-phase, capacitor-start, induction-run motor is one of the new products being exhibited by Newman Industries, Ltd., Yate, Bristol. This machine, which is described and illustrated on page 478 of this issue, is intended to meet the needs of agricultural users. Externally, the motor is notable for its smooth contours, the condenser being arranged in two units housed in the hollow feet of the motor frame. The centrifugal switch, which is housed inside the end shield at the non-driving end, is of simple design and the static part of the switch is hermetically sealed. Reference to the sectional drawing on page 478 will show the construction of the machine and the path of the cooling air.

(*To be continued*)

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

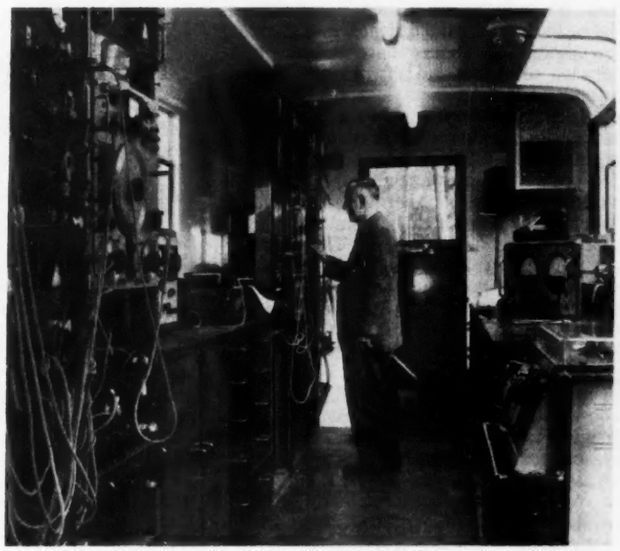
SAFETY COLOURS FOR USE IN INDUSTRY

No. 2929 : 1957. Price 4s. 6d. Recommendations to establish throughout industry the use of a universal system of colours for the identification of hazards and safety equipment are made in this new specification: as these recommendations are applied in factories, mines, shunting yards and other industrial installations, the confusion which now exists through the use of a variety of different colour codes should gradually be removed. The main advantage will be to associate in the minds of work-people certain colours and signs with particular kinds of hazard, an association of ideas which will not be upset should workers move to a different department in the same works or to a completely different factory or site. The new system has a greater significance in that it is in substantial agreement with the code of safety colours shortly to be recommended for world-wide adoption by the International Organisation for Standardisation. This International code, as it is taken up by other states, should help to safeguard workers moving from one country to another by establishing a universal and easily recognised safety-colour system. The new British Standard recommendations are extremely simple. The colours are red, orange-yellow and green, and advice is given in the standard on the selection of the right shades of these colours. Red has the meaning stop, orange-yellow means warning of danger, and green is used to identify or locate safety equipment and safety routes. Contrasting colours are used with the three main colours to form patterns which make for easier visibility. Geometrical forms—a circle, triangle, or rectangle—may be used as part of a safety message, but the colour in which they are painted and their meaning will always be the same.

New Mobile Laboratory*

By P. H. PARKIN, B.Sc., A.M.I.E.E.

For the past ten years the Building Research Station has had a mobile acoustics laboratory for field work. Examples are measurements of sound insulation between flats, of noise levels in buildings of various types, e.g. hospitals, and of reverberation times in auditoria. All these measurements have in common the use of microphones and often other acoustical apparatus, e.g. loudspeakers, which are connected by suitable cables to the laboratory. In the laboratory the incoming signals are metered, recorded or analysed as required. Recent experiments have needed more space than was available in the old laboratory. A new and larger one has therefore been designed and is now in use.



THE maximum legal size for an unarticulated vehicle of the type here described is 30ft long by 8ft wide, and while the largest possible internal space was desirable, the laboratory had to be reasonably manœuvrable on restricted sites. A scale model whose length, breadth and turning circle could be adjusted was used in conjunction with enlarged street maps of a few known difficult sites (e.g. the precincts of St. Paul's Cathedral) and from these tests it was decided that the best compromise would be a vehicle measuring about 27ft 6in long by 7ft 6in wide, with a swept turning circle of about 65ft. The obvious choice of chassis to give maximum internal space with the best manœuvrability was one with under-floor engine. It should be mentioned that a "mechanical horse" and trailer type of vehicle was not suitable: this laboratory makes several one-day measurements, and when it is away at one site for any length of time it is usually garaged locally at night for safety.

Layout

Fig. 1 shows the plan of the laboratory. The driving cabin has seats for two passengers (the usual staff complement for many experiments) with a driver's entrance door and a door leading to the "office." In addition to the desk this office contains the mains supply control panel and a sink. The laboratory space is separated from the office by a pair of centrally closing sliding doors. At the front end of this space there is a jack-knife door (down two steps) in the near side, and at the rear there is a central door opening on to steps which fold up and slide under the floor when not in use. The layout of the benches and of the six 19in Post Office racks can be seen in Fig. 1. All the racks are mounted on shock-isolating supports, and are 6ft tall.

Under the floor, and reached from the outside, are boxes for housing the cables (on drums) required for the work. There is a cat-walk along the length of the roof—reached by a ladder at the back—which is used for tying cables that have to go over pavements, and to reach the plastic dome. This can go in place of a glass panel in the roof over the office; a person standing on the bench can then see all round the laboratory, experience having shown that this is necessary in trials with low-flying high-speed aircraft. There are cupboards and shelves wherever it has been possible to fit them in, because the laboratory has to carry sufficient spares to be self-sufficient for some weeks. Including the cable boxes mentioned above, the total cupboard volume is 130 cubic feet, plus 50 square feet of shelving. The total bench and desk area is 40 square feet. There are windows in both sides of the vehicle, one in the rear door and one—already mentioned—over the office. Artificial lighting is by fluorescent tubes running the length of the laboratory and the office, plus 24V "emergency" lights from the vehicle battery. The ceiling is of perforated hardboard with rock-wool behind for sound absorption.

For a major overhaul of the engine it is necessary to get at the top of it, and this of course is usually done through traps in the floor. In this vehicle such traps would have seriously restricted the layout of the racks and benches. However, the engine can be expected to run some 200,000 miles before a major overhaul is necessary, because it is designed for use in long-distance coaches. The annual mileage of this laboratory is not great—between 5000 and 7000 miles—because the time spent in travelling is only a small proportion of the total "in use" time. Accordingly, the floor traps have been omitted.

Power Supplies

The laboratory has no internal power supplies—apart of course from the vehicle battery—and on site is always connected to a mains supply. However, there is provision for towing a generator if this should ever prove necessary. The incoming mains supply is metered and is then stabilised at 230V. The stabiliser can deal with incoming voltages of between 200V and 250V, but when the voltage is lower than this—as it is occasionally when a long run of mains cable is used—then an auto-transformer can be switched in which boosts the voltage by 30V. This stabilised supply is used for all purposes in the laboratory, i.e. the heating and lighting as well as the apparatus. The total possible load is greater than the available 13A to 15A and therefore a cut-out is fitted and all switches are marked with the current taken by their respective loads.

Heating

The main heating is by electrical wall-mounted low-temperature units (2kW). There is also 10W per square foot of electrical floor heating and this has the great advantage of keeping the floor dry in wet or snowy weather. The sides and roof are insulated with 2in of rock wool. However, the available power is only just sufficient to keep the temperature at 55 deg. to 60 deg. Fah. in cold weather, and it takes three or four hours to reach this temperature after arrival on site. Although there is a cab heater worked from the engine, this is too small to make any impression on the temperature in the main body of the vehicle. Additional heaters from the engine are being considered.

Of equal importance is keeping reasonably cool in hot weather. (In the old laboratory 104 deg. Fah. was once recorded.) All the windows have been fitted with blinds, and have opening lights. In addition, a small cooling unit has been installed. This, it is hoped, will extract some 2000 B.Th.U. per hour, and should make at least a few degrees difference.

Apparatus

The apparatus installed is the usual specialised equipment used for acoustical measurements and is not of general interest. It need only be mentioned that Post Office

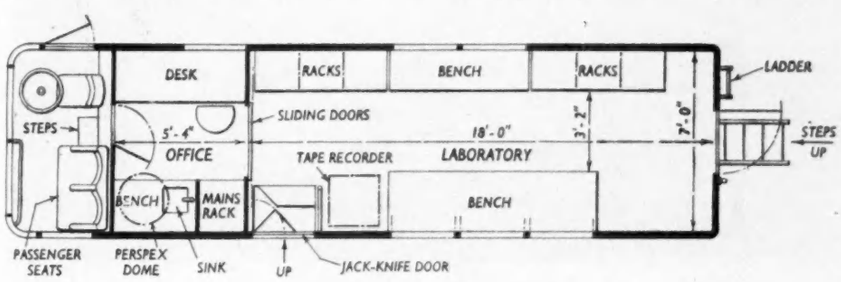


Fig. 1—Plan of mobile laboratory

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jacks are mounted on vertical strips between the racks and over the benches, thus enabling low-impedance connections to be made between the racks and the benches without trailing leads. An example of the advantage of the increased space available in the new laboratory is afforded by some current work on the propagation of sound in the open air. This calls for measurements about once a week over a year using ten microphones which are permanently installed over a mile-long stretch of airfield. The necessary ten measuring amplifiers, calibration and monitoring equipment, and multi-channel tape recorder can be left undisturbed in the front three racks while still leaving sufficient space for equipment for other measurements, e.g. of sound insulation in flats. The measuring cables for any experiments can be connected to two separate sets of input plugs on the exterior of the vehicle, the reason for the two sets being to prevent cross-talk between cables carrying signals at very different levels; a trap-door is available for cables which do not fit into this system.

Miscellaneous

A short-wave radio is installed, for communication either with the Station when within range, or with a "walkie-talkie" for short distance operations, as when servicing the ten microphones mentioned above. The water supply is from a 30-gallon tank under the sink bench, and the water is raised by a 24V pump through a 1-gallon electrically heated tank up to the sink. The main tank is filled from the outside. In the final design, the length had to be a little longer than originally planned to fit in with the constructional system. The overall dimensions are 28ft long (exclusive of the ladder) by 7ft 6in wide by 10ft 10in high. The internal height is 7ft and the fully laden weight is 9 tons 10 cwt.

Acknowledgments

This work is part of the research programme of the Building Research Board of the Department of Scientific and Industrial Research, and this article is published by permission of the Director of Building Research. The chassis is a Dennis "Lancet," the coachwork being by James Whitson and Co., Ltd. General assistance during the design and construction was given by the Wheeled Vehicles Department of the M.O.S.

Railway Modernisation at Barking

Reorganisation of the three railway routes which pass through Barking station is considered to be the key problem in the electrification of the London–Southend–Tilbury lines. Here we describe progress in track reconstruction and in building a new marshalling yard. The former is noteworthy for its complexity, and for the fact that services are remaining substantially normal throughout reconstruction.

THE Eastern Region of British Railways has two major constructional schemes in progress in the Barking area which form part of the general programme of modernisation and electrification to which the region is committed. Recent progress on these two schemes—the reconstruction of the junction at Barking station and the construction of a new marshalling yard—are briefly reviewed here.

At Barking station three routes are served, namely, from Fenchurch Street to Southend, from St. Pancras to Tilbury, and the London Transport District line from the City to Upminster. The track layout before the present scheme started is shown in the upper diagram of the illustration, from which it can be seen that the St. Pancras–Tilbury route crosses over the other two routes, on the level, and District line trains cross from one track to another on the up side of the station. This layout "evolved" over the years, as the railway system grew; now traffic has reached a pitch where 700 trains a day pass over the multiple crossings on the down side of the station, which have thus become a "bottleneck," restricting operation of all six main lines. The number of trains—freight and passenger—which now pass through Barking in a day are tabulated in the diagram.

The two schemes of reconstruction are described by the Region as the key to the whole of the London, Southend and Tilbury electrification, and, taken together, they are considered to be "one of the most complex railway engineering projects ever carried out." The main objects which they will fulfil are: (*a*) to run more passenger trains with greater punctuality, particularly on the direct Southend line, by eliminating crossing movements of freight trains to and from the Tilbury line; (*b*) to eliminate the present fouling movements across the local tracks which affect the running of trains on the District line; (*c*) to allow for the growth of freight traffic and to improve the working of freight trains to and from the Tilbury line by carrying them clear of the Southend and District lines; (*d*) improved passenger facilities at the station and, in particular, better interchange arrangements between Eastern Region and London Transport trains; (*e*) expansion of the Barking goods railhead by transferring it to a new site close to Ripple Lane marshalling yard; (*f*) new stabling sidings for London Transport trains east of Barking station.

Track Reconstruction at Barking

It will be clear from the two diagrams how the track layout is being changed at Barking. Both tracks of the St. Pancras–Tilbury line are carried over the other two lines on a flyover. The "up" track of the London Transport line is carried under the Fenchurch Street–Southend line on the "down" side of the station, through a tunnel, referred to as a "dive-under." On the "up" side of the station, this same track is then carried over the Fenchurch Street–Southend line, on a flyover, back to its original position. The sole purpose of this double crossing-over is to position the "up" District line and the "up" line to Fenchurch Street next to each other, as they pass through Barking station, so that passengers may change directly between the two from one platform. This arrangement is considered justified because of the rush-hour congestion which it will relieve.

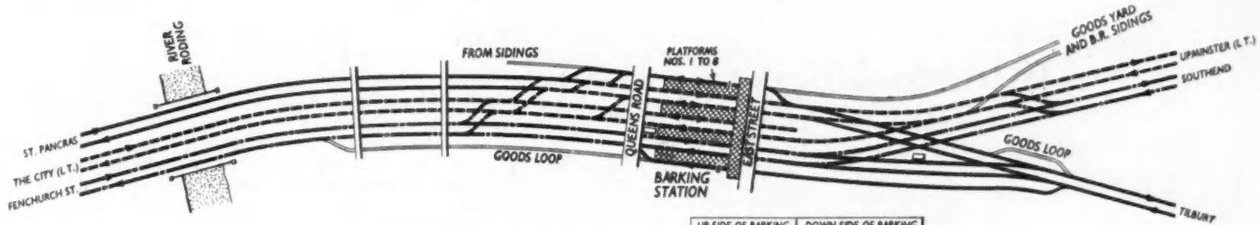
Other alterations in the track layout are subsidiary to those just described; they include, at platform three, a track for District line trains terminating at Barking, and rearrangement of goods and London Transport sidings.

There are two intermediate stages of track layout not shown in the diagrams, which will each be used for a time at different stages of construction. The whole aim of the civil engineering works—an aim which has influenced both the ultimate layout of tracks and the constructional methods employed—has been to keep all the lines in operation throughout the construction of the new scheme. For this reason, all the constructional methods employed are well tried and are characteristic of present-day railway practice.

The new bridge over the River Roding was built clear of the existing tracks, and was thus free from the operational complications which dominate the rest of the work, and has already been completed. It has three 56ft simply supported spans, each a built-up welded steel girder construction. The deck is of reinforced concrete, and there are mass concrete abutments and piers.

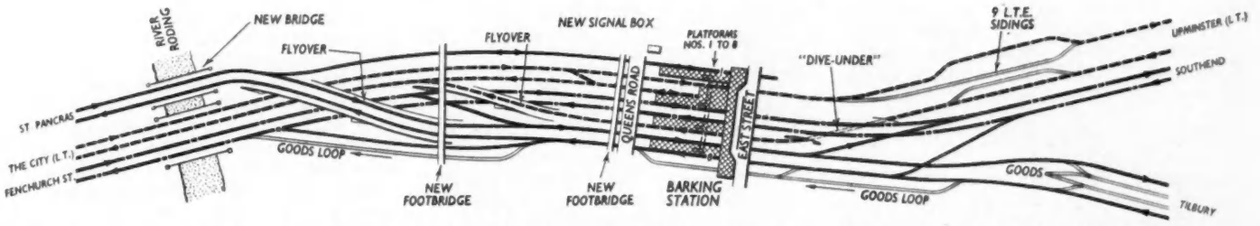
A length of the flyover structure contiguous with the Roding bridge has also been constructed, up to a point close to the lines in use; similarly, a length of structure at the opposite end of this flyover has also been built. Construction is in concrete, the deck of the flyover being prestressed, using the system of partial prestressing which has become common on the bridgeworks of the Eastern Region. "Holmpress" cast-in-situ

Fig. 2—Exterior of laboratory



DAILY AVERAGE NUMBER OF TRAINS USING THE SIX MAIN TRACKS.

		UP SIDE OF BARKING		DOWN SIDE OF BARKING	
		PASS.	FREIGHT	PASS.	FREIGHT
ST. PANCRAS - TILBURY:	UP	32	39	28	54
	DOWN	33	40	30	56
CITY - UPMINSTER (L.T.):	UP	238	17	172	16
	DOWN	233	22	177	7
FENCHURCH ST. - SOUTHEND	UP	95	41	74	6
	DOWN	89	45	70	17



Improved track layout at Barking. The upper diagram shows the existing layout with crossings at one level on the downside of Barking station. Barking station will also be rebuilt

piles carry the flyover piers. The Tilbury flyover will comprise three "intersection" spans and sixteen 40ft approach spans. The L.T. flyover will have the same number of approach spans, but only one "intersection."

Work is not yet so advanced on the second flyover, but the "dive-under" on the opposite side of Barking station is complete at its eastern end. Here, steel-sheet-piled enclosures are constructed and "tanked" concrete walls and invert built inside them. Tracks pass over on composite prestressed slabs. Automatic pumps will drain the dive-under.

Other works involved in the scheme are : (*a*) reconstruction of Barking station—so far work is under way only on the construction of the new subway ; (*b*) various retaining walls ; (*c*) two new footbridges which are largely complete. One of them is a steel girder bridge of ambitious proportions (it has to give clearance over the flyovers, as shown in the diagram), with a maximum span of 95ft. Again, it is of welded steel. The supports are reinforced concrete columns, which were precast and erected by railway cranes ; the heaviest of them weighs 15 tons. (*d*) A 30ft span road bridge in composite prestressed concrete, and lengthening another road bridge ; (*e*) a new signalbox. Reorganisation of signalling is, of course, part of the scheme and Eastern Region and London Transport traffic will both be controlled from the new box.

At the present time the new scheme is about 40 per cent towards completion. Work started in July, 1956, and completion is scheduled for December, 1959. The general plan of the two intermediate stages of layout to which we referred envisaged completing the perimeter works first, and then moving the tracks outwards progressively to give enough space to build the flyovers. Normal services are being maintained, except for one planned diversion. The work is under the direction of Mr. A. K. Terris, chief civil engineer, and the staff of the Eastern Region. The contractor is W. and C. French, Ltd., and the estimated cost of the civil engineering works out to contract is nearly £1,500,000.

Ripple Lane Marshalling Yard

The new marshalling yard at Ripple Lane has been planned to improve generally the working of freight traffic in the area. It is to be laid out with a modern mechanised hump yard with primary and secondary retarders, and with direct access to the reception sidings for both up and down traffic. It will replace five existing yards, i.e. the existing up and down yards at Ripple Lane, the up and down yards at Plaistow and the yard at Little Ilford. Movement of freight trains between these yards, which is unavoidable to-day, will no longer be necessary since fast through trains will run direct from Ripple Lane to their destinations, largely at night. The works extend for approximately 2 miles from Barking by-pass overbridge to Dagenham Dock station. They comprise, first, a set of eight reception sidings (capacity 557 wagons) with engine road ; secondly, a hump line, fanning into fifty-three sorting sidings with a total capacity of 3318 wagons and, finally, two each up and down departure sidings. Direct exit for traffic from certain of the sidings in the main balloon, as well as from the departure sidings, will be possible.

Structures include a new signalbox at the west end of the work (replacing two on the existing layout) ; a hump cabin, control tower and yardmaster's office, together with buildings for maintenance staff throughout the yard. Facilities will be provided for the inspection, maintenance and fuelling of diesel and steam locomotives, a 75ft diameter turntable, water column and ashpit. There will be a workshop for the repair of wagons on the north side of the site.

Prior to the start of work, the main lines ran through what is now the centre of the site and, on completion, the down main line will be to the north and the up main line to the south of the yard. At the present time, however, to give free access for the contractor, both main lines are diverted to the south of the site. In the course of the work, it has been necessary to demolish Renwick Road bridge and reconstruct it to a greater overall length. The reconstructed bridge will be of three spans, the centre span being 130ft and the side spans each 47ft. The structure is entirely in concrete and the deck is of prestressed concrete. The roadway is now carried on a temporary Bailey bridge.

Ground conditions throughout the site are extremely poor, the trial bores having indicated an average of 5ft of made-up ground, 14ft of peat, 8ft of ballast, all overlying an indefinite depth of sound clay. All structures, including the lighting columns, are therefore carried on piles. The total number of piles required is just over 1000. Piles, in general, are Holmpress or West's piles, founded in the ballast stratum. In the case of the new Renwick Road bridge, the pier and abutment loading of almost 2000 tons is expected to cause, ultimately, settlement of the ballast stratum by compression of the underlying clay, and the bridge is, therefore, designed as three simply supported spans.

It will be appreciated that the soil conditions have governed the design of the yard. Soil mechanics investigations indicated that, in general, the site would not carry more than 12ft of fill. The hump is therefore being formed by excavating all materials down to the ballast and then building up again with selected materials. Tests to date show that settlement of the hump is of the order of 3in and rate of settlement is decreasing rapidly.

The total quantities of excavation on the site are about 180,000 cubic yards and total fill required is about 520,000 cubic yards. Sulphate content of the ground water is 147 parts per 100,000 and all concrete work below ground level is, therefore, in metallurgical supersulphated cement.

The presence of no fewer than three overhead electric power lines and a large number of underground electric cables, coming from Barking power station, has necessitated very considerable diversions ; one of the overhead lines has already been diverted to the north side of the site and the others will soon be diverted clear of the site. Underground cables are being completely rearranged and will be carried under the tracks in two subways, one near Renwick Road bridge and another running under the centre of the main group of sidings. This latter subway is part of a combined structure, the other section serving as a culvert.

The whole of the civil engineering work, including practically all the permanent way, is being carried out by contract by W. and C. French, Ltd. Sir William Halcrow and Partners are the consulting engineers. The whole scheme is under the general direction of the Eastern Region's engineer.

Work was started on the main contract for the new yard in February, 1957 (preliminary work started the previous June) and at present the track work is about 60 per cent complete. The estimated cost of the works at Ripple Lane approaches £2,500,000.

Turbines for Vehicles

By F. J. WALLACE, Ph.D.,* and B. C. LOVATT†

There was read to the Institute of Road Transport Engineers in London recently a paper entitled "The Free Piston Gasifyer, with Special Reference to Vehicle Application," in which brief details were given of a new small free piston gas generator designed in this country.

NONE of the automotive gasifyers at present under development, including units by General Motors, Renault and Ford, not to mention the unit we ourselves are concerned with, have reached the production stage.

The most important work carried out in the States is that by General Motors, who acquired a S.I.G.M.A. licence for the GS.34 machine in 1953 and have accumulated a great deal of running experience on that machine. They have in addition, and in collaboration with the French, built a prototype automotive gasifyer of twin-cylinder construction. This machine, known as the "Hyprex," has a diesel bore of 4in and develops approximately 160 g.h.p. at an operating frequency of 2600 c.p.m.

In this country at least six firms, including the one with which we are associated, have acquired licences from Alan Muntz and a considerable building programme is now under way.

In the Table are the leading dimensions of the GS.34 and our own automotive gasifyer (designated CS.45).

The frequency range is relatively small, e.g. from 450 c.p.m. at no load to 600 c.p.m. at full load, the frequency being dictated by the stiffness of the elastic system comprising the pistons as oscillating masses and the various compressed gas spaces as springs. Hence, the greater the difference between gas forces at O.D.P. and I.D.P. and the lighter the moving parts, the higher will be the frequency of the gasifyer.

It may be observed that, at any one value of the gas delivery pressure, the mass flow can vary between very wide limits, depending on the stroke of the machine. This means that the gasifyer is very favourably placed with regard to meeting the mass flow characteristics of different types of turbines. In addition, there is, of course, complete absence of surge.

There are two points worthy of note regarding the limitations on the variation of stroke.

(1) Maximum stroke corresponding to maximum O.D.P. is limited by ensuring no collision of the compressor piston with the cushion cylinder head.

(2) Minimum stroke corresponding to minimum O.D.P. must be such as not to interfere with the "breathing" capacity of the gasifyer by covering part or the whole of the inlet ports.

Because of the reduction in mass flow which accompanies a drop in turbine admission pressure, a point is reached where the swallowing capacity of the turbine falls below the minimum possible delivery of the gasifyer. This contingency can be met either by the simple, but wasteful, device of "blowing off," i.e. discharging excess flow to waste, or more efficiently by modifying the path of air through the gasifyer.

At least three alternative schemes are in existence, viz.

(*a*) Recirculation, where air previously delivered to the engine case is returned to the compressor inlet.

(*b*) By-passing, where part of the air in the engine case is taken directly to the turbine, thus lowering both power and temperature.

(*c*) Intake throttling, which is self-explanatory.

Having considered the characteristics of the gasifyer, it now remains to examine those of the turbine itself. The characteristics of Fig. 1 apply to an inward radial flow type of turbine which is considered particularly suitable for vehicle application.

It is clear that these curves are of the form required, starting torque being approximately 1·8 times design torque. Furthermore, if the turbine is allowed to overspeed, the ratio starting torque/torque at maximum vehicle speed approaches 8 : 1, which is sufficient to meet even the most arduous conditions encountered by commercial vehicles. Superimposed on the diagram are curves showing the maximum available, and also the level torque, the difference between these two curves at any one speed representing the torque available for acceleration.

It will be seen that, in order to realise the full starting torque ratio of 8 : 1, the gasifyer must be capable of supplying considerable excess flow of gas, compared with the maxi-

TABLE

	GS.34	CS.45
Diesel bore	13·4in	4·5in
Compressor bore	36in	12·5in
Stroke	18in	5·44in
Frequency	600 c.p.m.	2200 c.p.m.
Gas delivery pressure ...	46 lb per square inch gauge	60 lb per square inch gauge
Gas delivery temperature	450 deg. Cent., 842 deg. Fah.	480 deg. Cent., 874 deg. Fah.
Gas horsepower	1250	196
Shaft horsepower	1000	160 approximately

* Associated British Engineering, Ltd.
† Free Piston Engine Company, Ltd.

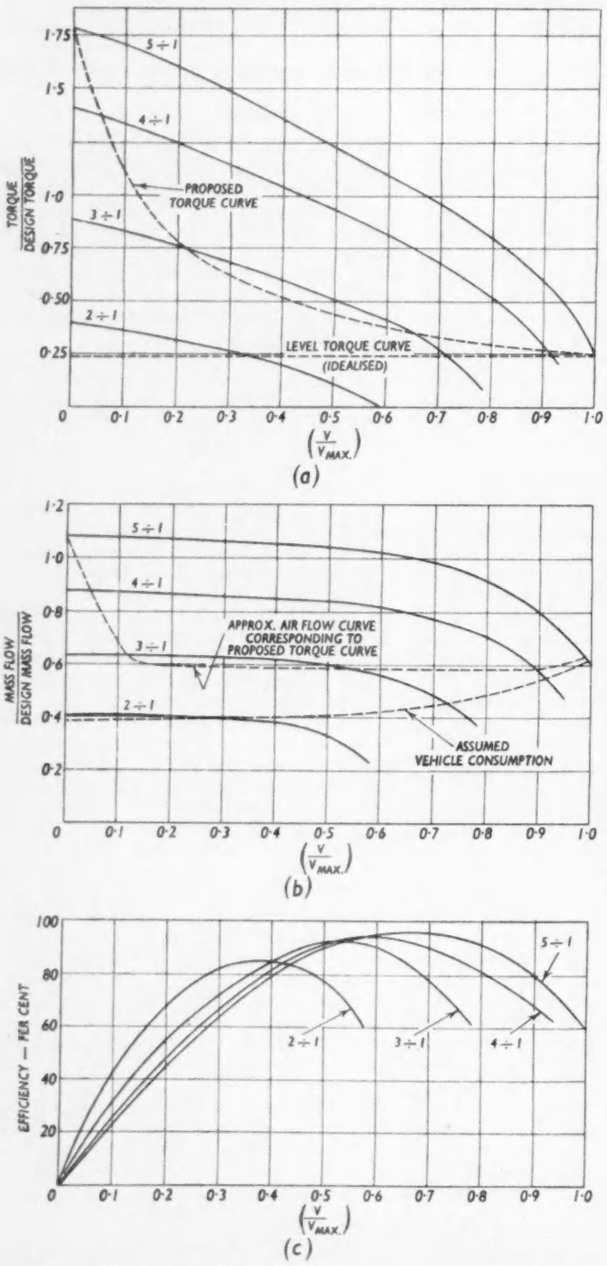


Fig. 1—Radial inward flow turbine designed for pressure ratio 5 : *(a)* torque characteristics, *(b)* mass flow characteristics, *(c)* efficiency characteristics

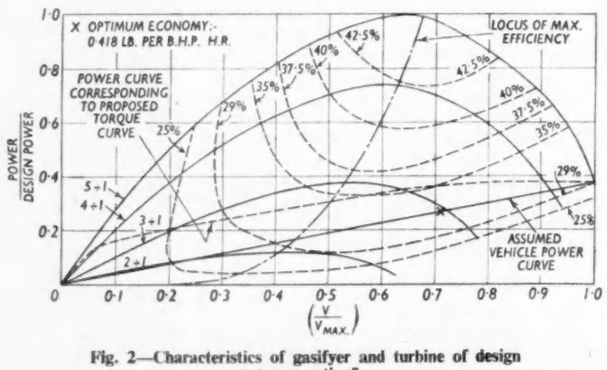

X OPTIMUM ECONOMY:- 0·418 LB. PER B.H.P. H.R.
LOCUS OF MAX. EFFICIENCY
POWER CURVE CORRESPONDING TO PROPOSED TORQUE CURVE
POWER / DESIGN POWER
ASSUMED VEHICLE POWER CURVE
(V/V MAX.)

Fig. 2—Characteristics of gasifyer and turbine of design pressure ratio 5

mum power maximum speed condition.

This is achieved by allowing the gasifyer to operate temporarily with a particularly long stroke and illustrates in yet another way the flexibility of the unit.

The characteristics of gasifyer and turbine are combined in Fig. 2, relating shaft power and overall efficiency (i.e. combined gasifyer and turbine efficiency) to vehicle speed.

It may be observed that the maximum efficiency is of the order of 35 per cent at a vehicle speed of 0·63 of maximum speed, and under accelerating conditions, whereas under normal conditions the maximum efficiency is limited to approximately 32 per cent.

Bearing in mind that a very simple transmission without change speed gearbox is used, these values must be considered very promising, particularly when compared with figures of less than 20 per cent for the "straight" gas turbine, even with heat exchanger.

In addition to higher efficiency, the gasifyer-turbine combination possesses the following advantages over the "straight" gas turbine :

(1) High efficiencies are achieved without the use of heat exchangers. It is fair to say that, at the moment, the biggest single obstacle in the path of progress of the straight gas turbine is the difficulty of evolving a satisfactory regenerative heat exchanger.

(2) Turbine inlet temperatures are low (450 deg. to 480 deg. Cent.) and as a result, normal ferritic materials of construction can be used, and there is no danger of harmful deposits, e.g. vanadium pentoxide.

(3) The most troublesome acceleration problem of the straight gas turbine, due to mechanical inertia of the gas generator section, and thermal inertia of the heat exchanger, is practically non-existent, the response of the gasifyer to changes in throttle setting being almost instantaneous.

In other words, when the operator puts his foot on the pedal increase in power to the wheels is instantaneous, while with a conventional gas turbine, the availability of full power is delayed due to the need to speed up the three rotors (say) and to thermal lags in the heat exchanger and associated equipment.

On the other hand, a reduction in throttle setting results in a delay before retardation is experienced.

Installation

An indication of the size of a 195 g.h.p. unit has already been given. The overall dimensions of this unit are approximately 50in long by 20in high by 18in wide. The specific weight of the complete unit, comprising gasifyer with control gear, turbine and turbine reduction gear, will be of the order of 12 lb per shaft horsepower, of which rather more than two-thirds are accounted for by the gasifyer. This gives a gasifyer weight of 1280 lb, which must be compared with the dry weight of conventional diesel engines of the order of 150 b.h.p., viz. 1400–1600 lb.

The turbine is of very compact dimensions indeed, the speed of rotation being of the order of 60,000 r.p.m. and the rotor diameter approximately 5in. The turbine weight is approximately 300 lb and the complete unit, as defined above, is expected to weigh not more than 1950 lb.

Since gasifyer and turbine are mechanically independent of each other, they can be installed in the vehicle in practically any way that is convenient.

In most cases the turbine and reduction gear would be mounted in close proximity to the driving wheels, whereas the gasifyer itself could be located at any point in the vehicle suitable both from the point of view of weight distribution and that of general convenience.

Starting of the unit is effected most conveniently by compressed air, the pistons first being manœuvred into the O.D.P. position, compressed air then being admitted to both cushion cylinders and the piston assemblies finally being released and forced together under the action of the cushion pressure. In the case of a vehicle this necessitates provision of an electrically-driven auxiliary compressor.

The only control directly operated by the driver is the fuel pump rack which, of course, governs the amount of fuel supplied to the gasifyer.

All other gasifyer controls are fully automatic ; these include :

(*a*) Cushion control, which adjusts the amount of air trapped in the cushion cylinder to give the correct diesel engine compression pressure irrespective of the applied load.

(*b*) Fuel injection timing control which is operated by a cushion pressure sensing device and ensures that injection timing is adjusted in accordance with the changes in I.D.P. resulting from changes in load.

Auxiliaries include the following :

(*a*) Cooling fan, driven by a small, separate exhaust turbine.

(*b*) Lubricating pump driven from pinion rocker shaft, as is also the fuel injection pump.

(*c*) Electrical generator, driven either from transmission or auxiliary turbine.

(*d*) Air compressor for starting and braking systems.

(*e*) Cooling water circulating pump.

Fuels.—In common with all other gasifyers, the automotive unit will operate satisfactorily with a wide range of fuels from 100 octane petrol to heavy residual fuels of 2000–3000 seconds viscosity. The latter case is of academic interest only, since it would entail the addition of preheating and pretreatment equipment.

However, the ability of the engine to burn the entire range of distillate fuels, together with the lighter non-distillates, constitutes a very real advantage, not only from a military point of view, but also for vehicles intended for export to countries with widely differing conditions.

Progress with Xerography

At a conference held in Coventry last week the application of xerography was described by speakers from Coventry Corporation and the English Electric Company, Ltd., Stafford. The xerographic process of graphic reproduction, invented ten years ago in America, is used for making master copies for use with the offset litho process. In this method, a metal plate coated with a thin layer of selenium is exposed to a high d.c. voltage, which induces an even charge in the selenium. On exposing the plate under a negative or in a photographic camera, or to the action of X-rays or gamma-rays, the selenium is discharged in those places where it was acted on by the radiation. When dusted with a fine powder the hitherto latent image is "developed," owing to the fact that the powder adheres only to the charged portions. The powder is then transferred on to special paper by means of a second electrostatic charge, and is fixed by fusing it into the prepared paper surface. The original plate can then be reused. The process, which is handled in this country by Rank-Xerox, Ltd., 33–41, Mortimer Street, London, W.1, is stated to take about one-fortieth of the time required for making a photocopy and to cost only one-eighth to one-tenth as much.

Obituary

LIEUT.-COL. G. R. S. WILSON, C.B.E.

We record with regret the death of Lieut.-Colonel George Robert Stewart Wilson, which occurred suddenly, in London, on Thursday, March 20. Lieut.-Colonel Wilson, who was sixty-one, had been Chief Inspecting Officer of Railways, Ministry of Transport and Civil Aviation since 1949.

Lieut.-Colonel Wilson was educated at Marlborough and at the Royal Military Academy, Woolwich, and served with the Royal Engineers in France and Macedonia throughout the first world war. After the war he was on the Colonial Office staff for some months, and was subsequently appointed an instructor at the Railway Training Centre at Longmoor, Hants. Lieut.-Colonel Wilson joined the railway inspectorate at the Ministry of Transport in 1935, but was recalled to military service on the outbreak of the second world war. From September, 1939, until June, 1940, he was assistant director of railways with the British Expeditionary Force in France. After the evacuation from Dunkirk, he resumed his work with the railway inspectorate at the Ministry of Transport and was appointed an inspecting officer in 1941. Lieut.-Colonel Wilson succeeded to the post of chief inspecting officer in 1949.

As chief inspecting officer, Lieut.-Colonel Wilson was, of course, responsible for the very searching investigations that are made by the Ministry of Transport into railway accidents. The inquiries that are conducted are fully reported upon, and Lieut.-Colonel Wilson showed outstanding ability in the conduct of these inquiries. In recent years, he personally conducted the inquiries into the serious railway accidents at Harrow, Barnes and, quite recently, at Lewisham. At the time of his death, he was completing his report on the circumstances of the Lewisham disaster. In recent years he had visited the U.S.A. and France to study safety methods in railway operation ; he was also responsible for advising the Minister of Transport on the system of automatic train control adopted by British Railways. Lieut.-Colonel Wilson was a permanent member of the International Railway Congress Association. His C.B.E. was conferred in 1953.

Lieut-Col. G. R. S. Wilson

LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

RAILWAYS INTO ROADWAYS

SIR,—The two letters in your issue of March 14, against the conversion of railways into motor roads, seem to show that the Proceedings of the Institution of Civil Engineers Conference on the Highway Needs of Great Britain, November, 1957,* have not yet received the wide attention they deserve. No one having studied those proceedings would lightly dispute the estimate of £500 million as Britain's annual loss from road traffic delays ; for it is based on the calculations of the Director of Road Research, set out in Conference Paper No. 1, which show that £36,500,000 a year would be saved by speeding up Britain's road traffic by 1 m.p.h., without pricing the time of people delayed outside their working time. Whether that time should be priced, and the precise speeds at which traffic could reasonably be expected to flow, were subjects of debate at the conference; but finally none of the 800 delegates questioned the conclusion reached by Mr. Brunner in Paper No. 9 that in monetary terms the economic loss cannot be less than £500 million a year. But whatever the figure, it is increasing. The Director of Road Research, again in Paper No. 1, showed that owing to a 7·4 per cent annual increase in traffic the time cost of delay is increasing at over 14 per cent each year. "Frightening" was the word for it according to one delegate ; and him it was that Sir Herbert Manzoni elected to quote when summing up.

However, it is on an even broader issue that your two correspondents are primarily in conflict with the Civil's Highways Conference. The conference presumed—almost as a matter of course—that the aim must be to expand the highway system ; they saw freedom of movement as a boon. Your correspondents, Mr. Reynolds and Mr. Cule, on the other hand, see it as an evil, or at best, as too lethal and expensive a luxury. Study of the proceedings might bring them round to the view of the conference, for the papers and discussions reveal innumerable, well proven methods of rendering road movement less lethal and less expensive. Britain has hardly begun to adopt those methods ; there is tremendous scope for improvement. For instance, there is as yet virtually no segregation of speedworthy motor traffic in Britain. But segregation could be the key to the whole problem; that is the sense of one of the sections of that highly authoritative Paper No. 1 already quoted. The operative sentence of that section reads : "A new system of roads to be used by motor traffic is needed."

How, it may be asked, can Britain possibly be given a new, separate motor road system, distinct from the highway system, covering every county, serving every town and city ! It is something we could never afford. But we have it already—in all its essentials : our 19,000 mile railroad system. And miraculously we do somehow afford it. It will consume no less than £170 million in capital expenditure this year, and the same amount next year, as the Minister of Transport and Civil Aviation let fall when opening the Highways Conference—inadvertently, no doubt. To that sum must be added British Railways annual deficit (£57,500,000 in 1956), less its depreciation content of about £25,000,000.

How refreshing to turn from the woolly sociology of Mr. Reynolds and Mr. Cule and get on to a hard cash basis, dealing with worthwhile sums. £200 million a year is what the railways are draining out of the exchequer directly. Indirectly, by remaining railways instead of moving with the times and becoming roadways—the very motor roadway system prescribed by the Director of Road Research—they are primarily to blame for that £500 million a year wasted on highway traffic delays. Finally, to arrive at a really glorious sum, let there be a Railways Conference on the lines of the Civil's Highways Conference, to work out the economic loss the country is suffering because of the railways' failure to provide door-to-door transit at 25 m.p.h. in urban areas and 40 m.p.h. in rural areas. Those were the modest par speeds on which the Highways Conference utterly condemned the present-day highway system of Britain.

T. I. LLOYD

London, E.C.1,
March 21, 1958.

SIR,—It is fairly obvious that those road addicts who advocate tearing up our railway lines are blind to the 6000 deaths and 33,000 injured which is the annual toll of our existing roads. It must be equally obvious that the contrasting high degree of safe travel on our railways is the outcome of a 100 per cent signalling system, the like of which could never be installed on any system of roads, carrying unlimited numbers of vehicles. Moreover, it is clear that a rubber-tyred vehicle moving on a wet or an ice-bound road, cannot be controlled on its proper course with anything like the precision of a train having flanged steel wheels running on accurately gauged rails.

When one sees a large car overturned on the slope of a road cutting on a wet December afternoon, one realises the defects in road transport which have yet to be tackled ; problems which are not solved just by asserting that the driver should have been more careful.

Judging by the performance of the new diesel trains, I am convinced our railways, when modernised completely, will win against any road competition for at least another 100 years. Here is a useful local comparison of rail versus road : the journey by diesel train from Cheltenham to Gloucester City takes twelve minutes ; by car or motor scooter twenty to twenty-five minutes according to traffic density, and by bus around thirty minutes.

E. W. J. TRILLO

Cheltenham,
March 20, 1958.

SIR,—One aspect of this problem which does not appear to have been discussed in the recent correspondence is the labour which would be required to operate the service on the roads converted from railways. There should be no difficulty in operating a coal train with a net load of 1000 tons at an average speed of 30 m.p.h. on a main line railway, particularly after fitting continuous brakes to goods vehicles. To do this requires three men—a driver, fireman and guard, together with ancillary workers, such as signal men, maintenance men and others. Of approximately 550,000 railway workers, drivers and firemen comprise about 12 per cent, so that the operation of our 1000-ton goods train requires altogether something like sixteen men on a statistical basis. Now let us suppose that the same load has to be conveyed in 10-ton road vehicles. There will be 100 of these, each with a driver (and possibly a second man accompanying the driver). To these 100 drivers must be added men required for maintenance of vehicle and road, traffic control, and other purposes. The total labour force to move this 1000 tons of coal would be at least six times and probably ten times as many by road as by rail. In the unlikely event that the road vehicles could average 60 m.p.h., three to five times as many men would be required. In a small country like ours, where the population cannot increase indefinitely, the correct policy should surely be to have the greatest possible number of people employed in production and reduce non-productive labour, such as transport, to a minimum. Thus, a change from rail to road transport would appear to be a move in the wrong direction.

Complaints sometimes arise in connection with transport by rail by reason of delay and damage to goods. Would it not be possible for the railways to provide a flat vehicle capable of carrying one or more road vehicles? The road vehicle could be driven on to the rail truck at the beginning of the journey and collected again at the end of the trip. This would avoid loading and unloading goods in transit and free the main roads from much of the long-distance traffic. The time of departure of the freight train would be advertised and the road operators would have to arrive at the railway depot at the specified time. The drivers would then pick up motor vehicles arriving from other parts of the railway system and drive them to their destinations. It would require good organisation to ensure that drivers were always available to meet vehicles at the conclusion of the rail journey, but the difficulties should not prove insuperable, and the advantages, both to the railways and the roads might be considerable. I think some such plan as this might be worth

* Obtainable from the Secretary, the Institution of Civil Engineers, Great George Street, London, S.W.1. Price £2 post free.

studying and might provide a better solution to the problem than the drastic proposal of Brigadier Lloyd.

W. D. SPENCER

Welwyn Garden City,
March 18, 1958.

METHODS OF TEACHING MECHANICAL ENGINEERING SUBJECTS AT UNIVERSITIES

SIR,—Although Professor Burstall's Chairman's Address to the North Eastern Branch of the Institution of Mechanical Engineers was given in October, 1956, it has only recently been generally available (" Methods of Teaching Mechanical Engineering Subjects at British Universities," *Proc. I.Mech.E.*, 171, No. 12). In it he emphasises the need for training in design which I have previously stressed in your columns (THE ENGINEER, 195, 724 ; 198, 291). It is still unfortunately true that not nearly enough is being done in this respect in our universities.

But perhaps the most important thing that emerges from Professor Burstall's analysis of the situation is the impracticability of teaching the whole gamut of mechanical engineering to one and the same individual. Some mechanical engineers require to be " engineering scientists," trained in the basic disciplines: this is the more pressing now that physics departments have become so dazzled with cyclotron minding that classical physicists are almost extinct. Again, our project engineers are essentially concerned with a technical management job in a limited sphere ; they must be able to explain cogently, both by word of mouth and on paper, what is required, what is happening and what has been achieved. The design engineers must apply the fundamental results of their colleagues and others to yield new devices ; synthesis is notoriously more difficult than analysis and this requires a spark of the divine fire of inspiration.

We require engineers who are scientists, who are managers, who are artists (in the best sense of that much misused word). How can we expect to produce all from the same mould ?

Some people would say that this can be met by different universities specialising in each type of engineer needed. I believe this is fallacious for two reasons : first, neither the selection of men nor the man's selection of university is perfect. But more important, for all that I have subdivided the species " mechanical engineer," there remains an essential unity in the profession and the mutual education provided by the various types is no small part of the value they can get from a university. University Departments of Mechanical Engineering should cater for as wide a variety of men as possible.

Professor Burstall's stimulating address should be widely read. It is to be hoped that action will follow in many universities.

EWEN M'EWEN

Sevenoaks,
March 19, 1958.

M. A. ALDERSON

SIR,—I wonder if any reader could tell me the full name and the year of birth and death of M. A. Alderson. He wrote a book on steam engines, which was published in London in 1834 and won a prize from the London Mechanics' Institution (now Birkbeck College). He was a member of the latter from 1832 to 1834, during which time he lived in London. He was a civil engineer, and his home was in " Holbeck, near Leeds," in 1834, according to the way the preface of his book is signed. In 1825–26 M. A. Alderson also received a prize from the Royal Society of Arts (London) for a set of working drawings of a steam engine, and is there listed as from Manchester.

I thought, if you published this letter, some reader might be able to supply me with the information I need. It is required for a book now in preparation.

JOHN F. JONAS

30, Northgate Road,
Riverside, Illinois, U.S.A.,
March 20, 1958.

Book Reviews

The Modern Port. By H. FUGL-MEYER. Danish Technical Press. Vester Farimagsgade 31, Copenhagen V., Denmark. Price Danish Krone 22.50.

THIS book is an attempt to produce a combined technical and practical description of the many and varied problems associated with cargo handling at ports and to put forward suggestions to improve the general flow of cargo. The volume opens with an examination of the distribution of capital investment in a port and some general comments upon ships. There follow sections dealing with basins and quays and touching upon construction and equipment, while the next chapter discusses the general rules for transit sheds together with such items as optimum dimensions, lighting, and essential fittings and mechanical gear for handling cargo. Warehouses are briefly mentioned and there are directions for designing transit sheds and warehouses for general cargo, followed by notes upon railways, roads, rear areas, berthing of lighters, passenger landing stages, oil ports and fishing ports. Mechanical appliances for vertical transportation are dealt with extensively as are also the various items of equipment employed for horizontal transportation. Examples of time studies of port operation are included and there are notes upon the customs authorities and port administration.

Urban Motorways. British Road Federation, 26, Manchester Square, London, W.1. Price 55s.

A COMPLETE record of the international conference on urban motorways, organised by the British Road Federation and held in London at the end of 1956, is contained in this volume. A fairly comprehensive account of the conference, together with editorial comment, was given in THE ENGINEER at the time. The complete record in this volume, will, however, prove of value. The motor road in the large urban area is one of the greatest needs in this country, and in other countries, to-day. Its design, its economics and its relationship to other aspects of city planning are not yet fully understood. But a constructive approach to these problems, and examples of recent achievements and thought on the subject, will be found in this volume. Other events since the end of 1956 have tended to obscure the importance of the urban motorways conference. In particular, a road programme of some size has been initiated. There is little indication yet, however, of serious attempts to tackle the urban traffic problem. It can be hoped, therefore, that this volume will help to bring the problem to the fore once again.

Engines for Small Power Craft. By P. N. BARNARD. George Newnes, Ltd., Tower House, Southampton Street, Strand, London, W.C.2. Price 16s.

THIS book is intended for those concerned with the selection, installing or the running of small marine engines which develop up to 60 b.h.p. There are six chapters and the first three are factual in that they are surveys of diesel engines, petrol, paraffin and vaporising oil engines and outboard motors respectively. Each chapter presents in condensed form the principal items of design and technical data, of a large number of engines, and sufficient to convey a broad general idea of an engine and its performance. Chapter IV is concerned with the preparation of the boat ready for installing an engine and deals with such items as engine bearers, couplings, cooling systems, fuel systems, propellers and the choice of stern gear. The next two sections discuss the various problems of operation and maintenance and the diagnosing of troubles, and the volume concludes with the relevant sections of the Thames Launch Byelaws, recommendations of the Ship and Boat Builders National Federation, a note on the engines approved for lifeboats, and an engine selection index.

Earth Pressures and Retaining Walls. By W. C. HUNTINGTON. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 92s.

THE principles of soil mechanics are applied specifically to retaining wall design in this volume, which is intended primarily as a reference book for the structural engineer. It is an American publication, the author being emeritus professor of civil engineering at the University of Illinois. An introductory chapter classifies the various uses of retaining walls. There are then two long chapters on soil mechanics, the first dealing with earth pressures and their analysis in cohesionless soils, and the second with the corresponding properties of cohesive soils. The last three chapters deal directly with retaining wall design. In the first of them, foundations are discussed, together with problems of stability —stability against overturning, and against failures, including deep-seated failures, of the earth slopes. Design principles and requirements—related to concrete and reinforced concrete—are then explained. Lastly, a chapter on " Retaining Wall Design " explains steps in the design of the different categories of wall—solid gravity, semi-gravity, cantilever, and counterfort walls.

Books Received

Aerodynamics. Butterworth's Scientific Publications, 4 and 5, Bell Yard, London, W.C.2. Price 7s. 6d.

Directory of Opportunities for Graduates. Cornmarket Press, Ltd., 1, Lower James Street, London, W.1. Price 8s. 6d.

Air Pollution. Edited by M. W. Thring. Butterworth's Scientific Publications, 4 and 5, Bell Yard, London W.C.2. Price 42s.

Electronic Engineers Reference Book. By L. E. C. Hughes. Heywood and Co., Ltd., Ingersoll House, 9, Kingsway, London, W.C.2. Price 84s.

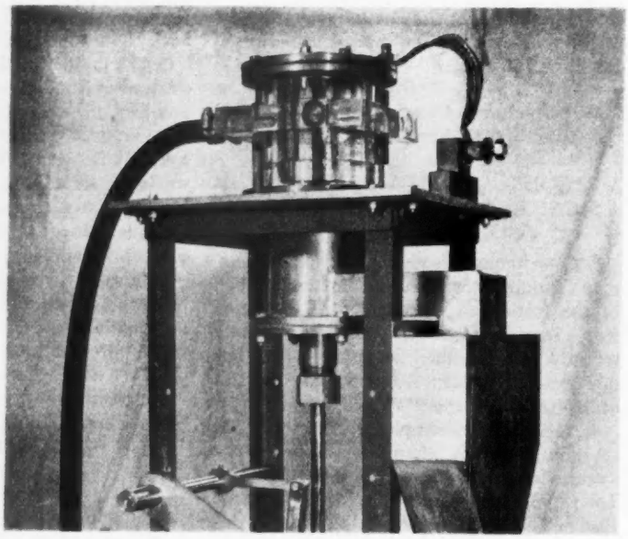
Industrial Electronics. By Andrew W. Kramer. Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, London, W.C.2. Price 36s.

Automobile Engine Overhaul. Fourth Edition. By A. W. Judge. Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, London, W.C.2. Price 15s.

Exhibition of the Physical Society

No. I

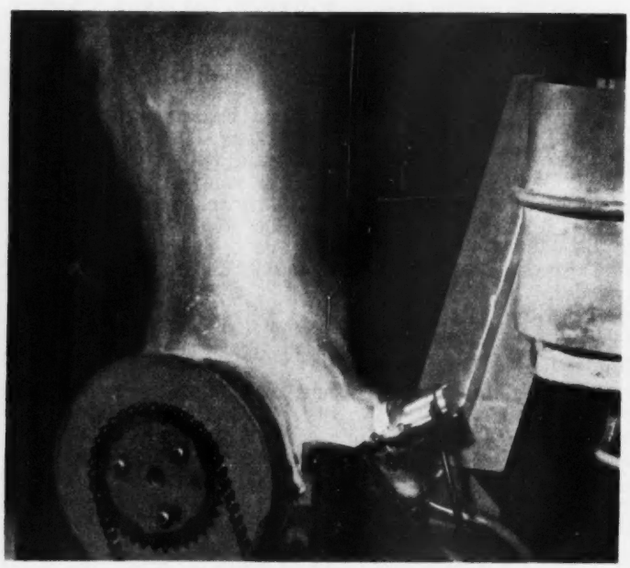
There opened last Monday the forty-second Physical Society's Exhibition, which continues at the Old and New Halls of the Royal Horticultural Society until Thursday next. On Monday, Tuesday and Wednesday evenings there were given discourses, of which the first dealt with Goethe's Colour Experiments. We describe below some of the exhibits of engineering interest.



THE exhibition this year is again remarkable for a demonstration by the Royal Aircraft Establishment of an advanced experimental technique, this taking the form of a plasma jet such as is generally used to investigate the kinetic heating of bodies during re-entry to the earth's atmosphere. The arc is water stabilised ; the apparatus resembles the swirl chamber of a spill burner, with the anode, a carbon rod entering through the spill passage. Where the nozzle of a sprayer would be there is a carbon disc acting as cathode, and in the centre of it there is a ¼in hole forming the nozzle. When an arc is struck, steam issues through this nozzle at temperatures up to 12,000 deg. K and speeds of thousands of feet per second, it is claimed. The apparatus consumes about 25kW : a Crown copyright illustration is reproduced above.

An interesting equipment for the non-destructive testing of materials is now being produced by A. E. Cawkell, Electronic Engineers. This reproduces the test of striking a specimen and listening to the " ring " that is emitted : when the decay of the oscillation is measured quantitatively, this is probably one of the most sensitive of non-destructive tests, and, we are advised, will indicate hardening or fatigue effects, stresses, crystallisation, and even magnetic effects. To measure logarithmic decrement a logarithmic damping attachment—LDA(M)—has been evolved which gives results in terms of " Q," where $Q=\pi/D$, D being the logarithmic decrement. The form taken by the presentation is a number recorded on four " Dekatrons," this being the number of cycles needed for the amplitude to fall from one level to another exactly one-half as great, and " Q " is obtained by multiplying by $\pi/\log_e 2 \simeq 4 \cdot 5$. The accuracy is, as this approximation suggests, about ± 1 per cent, but deteriorates for $Q<450$ because the counter can record only to the nearest whole number : for $Q<200$, as in concrete or bricks, the " S.C.T." equipment can be used, and Q inferred from the bandwidth over which the amplitude is $1/\sqrt{2}$ of that at resonance for a constant excitation. Because of the exceeding sensitivity of the property measured, samples must be supported and excited in a strictly controlled manner : electromagnetic excitation and pick-off is common, but a technique of eddy current excitation has been proven satisfactory on turbine blades of non-magnetic metal. In the application of quality control to carbon rods of nuclear quality, it was necessary to attach steel armatures to the rods. Unless a special instrument and method of mounting can be justified by the value of the results, the specimens must have a fundamental or overtone frequency in the range 2 kc/s to 20 kc/s (10 kc/s if the oscillator used is that of an " S.C.T.") which implies, in general, that the specimen be at least 6in in one dimension : there is virtually no upper limit of size, but a test bench is available for samples up to 1ft long. Confirmatory tests will probably be necessary to determine whether a variation in " Q " is due to flaws, layering, lack of bond, faulty welds, cracks or porosity.

Illustrated below is a radiation pyrometer which is the subject of experiments by the Research Laboratories of The General Electric Company, Ltd. The active element is a set of welded copper-eureka thermocouples : the hot or " target " junctions of the thermopile are enclosed in an aluminium cavity and the cold junctions of the thermopile are bonded thermally to the cavity wall, but remain electrically insulated from it.



Radiation pyrometer in use : the radiation from the surface is carried to the instrument by total internal reflection in a quartz probe

In use a narrow pencil of radiation is allowed to reach the " target " junctions and these then take up a temperature above that of the surrounding cavity. If the rise in temperature of the target is small and the aperture is also small, the electrical output is a measure of the intensity of radiation reaching the instrument and shows negligible dependence upon the temperature of the case, at least over the normal range of ambient temperature.

The device can be used with a quartz probe to collect radiation from the surface of a steel component during progressive induction hardening, because, with the end face of the probe close to the heated surface, the signal is not affected by the smoke or spray from the oil quench, nor the instrument by magnetic fields. A protective quartz sheath surrounds the probe to keep it clean, so that its property of total internal reflection is unchanged. As a direct or radiation pyrometer temperatures down to 100 deg. Cent. can be measured : with a double pinhole collimator, the instrument can be used to trace isothermals around such a source as a weld. The advantages anticipated are the compactness and simplicity of the pyrometer.

An extension of the accepted techniques of adhesion was shown by Mullard, Ltd. Readers may be aware that soft metals had been joined without heating by pressing flat, clean faces together, but this demonstration illustrates that cold welding can be applied, by the use of an ultrasonic generator, to metals which form an oxide film in air.

The junction of the two metals is pressed together and one metal made to vibrate laterally, " wiping " itself over the other. This has the effect of removing oxide films and other contaminants. The static thrusts required are quite small (up to 300 lb on a 1in radius tip) and the consequent deforma-

tions are small. Welding is more easily achieved in the softer metals, such as aluminium, copper or nickel. There is a limiting thickness for one of the metals (the vibrated one) to be joined (for example, 0·50in for aluminium), but no restriction on the thickness of the other. The demonstration equipment uses a vibration frequency of 22 kc/s with an ultrasonic input of up to 2kW to the laminated nickel magnetostrictive transducer.

Johnson, Matthey and Co., Ltd., displayed several platinum alloys for various applications, among them the 23 per cent cobalt permanent magnet material. Even "Alnico" is not, we are advised, half as powerful magnetically as this material after an ordering transformation. The heat-treatment, though critical, is reasonably simple; for example, cooling from 1000 deg. to 200 deg. Cent. in ten minutes and holding at 600 deg. Cent. for five hours. This permanent magnet material is unique not only in that it is the only one known to harden by an ordering mechanism rather than a precipitation reaction, but also in that it is ductile before heat-treatment and hence lends itself to manufacture. With an energy storage $(BH)_{max}$ of 9×10^6, such alloys are used in the Hamilton electric wrist watch which runs for a year on a miniature dry cell.

Apparatus for the remote reproduction of documents up to 14in by 8½in was demonstrated by Muirhead and Co., Ltd. The latest "Mufax" equipment, these long-distance facsimile machines work in the audio frequency range and need only a simple land line between transmitter and receiver. The original is loaded on to a roller on the transmitter with its length along the axis, being held in place by a transparent flexible sheath. The rolled original is then rotated in front of a spot of light which traverses slowly down the length of the roller : the amount of light scattering from the surface of the document is measured and forms the signal to the transmitter. The copy is formed on a continuous roll of sensitised paper which is darkened by passing an electric current through it : the receiver can work completely without attention, shutting down as soon as each transmission is completed. Scanning of the paper is achieved by the normal Muirhead technique of trapping the paper between a metal straight edge, representing the path of the light spot during one revolution of the original, and a helix rotating at the same speed as the roller and defining the instantaneous position of the spot. Reproduction is in an approximation to black on white.

The miniature recorder shown by the Medical Research Council was designed to be able to record physiological variables from unhampered subjects. The weight of the prototype is 2½ lb complete with batteries sufficient for 100 hours, and its dimensions are 6½in by 5in by 3in. It is thought that the commercial version of the instrument may only be about two-thirds of this size. The input to the recorder can either be in the form of a resistance change, a small potential, or change in potential. The general principle is that of a self-balancing Wheatstone bridge or potentiometer. The unbalanced voltage is amplified by a direct-coupled transistor amplifier which feeds a sensitive moving coil relay. This in turn energises a servo motor which drives a contact along a slide wire, thus rebalancing the bridge, and also drives the stylus across the chart.

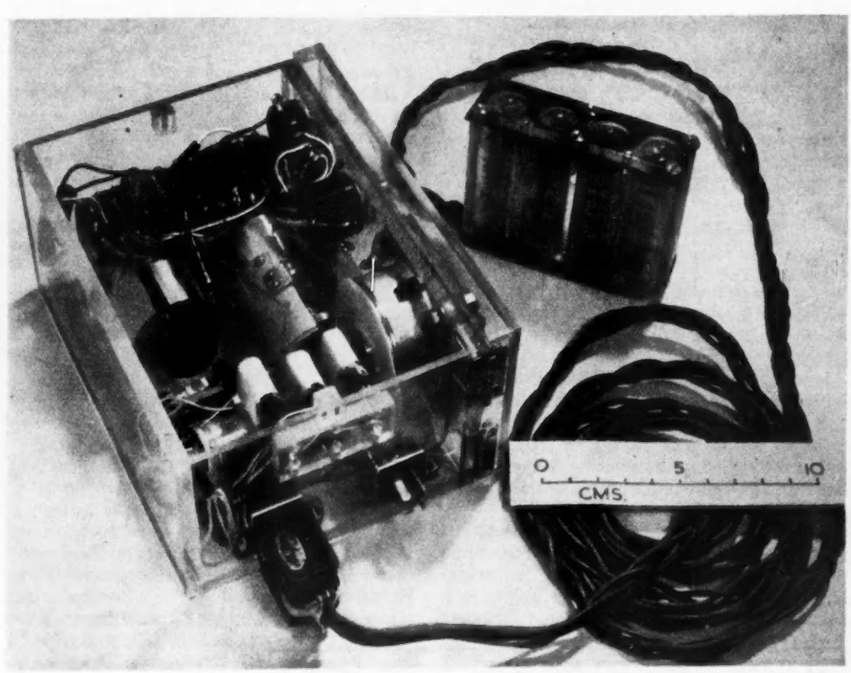
The instrument is intended to work over a temperature range of −50 deg. to +50 deg. Cent. It is difficult to design a direct-coupled transistor amplifier of a gain of 2000 which will remain free of appreciable drift (50–100μV referred to input) over that temperature range. The amplifier in use is therefore of a simple balanced type with a few preset controls to compensate for individual variations in transistor characteristics. The amplifier is rebalanced every fifteen minutes by the closure of a contact in the chart drive. When this contact closes, it energises a relay which removes the input from the error amplifier and switches the amplifier output to a second servo motor driving a potentiometer (which forms part of the amplifier circuit) in such a direction as to rebalance the amplifier. The thermal insulation and thermal capacity of the aluminium block in which the amplifier is housed is such that it is most unlikely that the temperature changes during any period of fifteen minutes will produce an amplifier drift which will give a visible excursion of the stylus on the chart, even though it may be sufficient to bring the rebalancing system into action. It can be argued that the drift correcting system might have been avoided by the use of a condenser coupled amplifier preceded by a mechanical chopper or electronic modulator. The reason that this was not done was that the mechanical chopper would have required too much power to allow operation from small dry batteries, while the electronic modulators are not sufficiently stable to give a 50–100μV resolution at the input.

The main servomotor is a special low inertia type made by Electro Methods, Ltd., fitted with an integral 500 : 1 gearbox. The motor has a very low power consumption ; it will run at 1000 r.p.m. for an input of about 10mW. The output shaft of the gearbox has been extended and carries a brass lead screw of 8 t.p.i. On the lead screw there is a nut which carries the stylus and which is virtually free from back lash and shake, having been made by casting it around the screw. The stylus is of steel with a silver point which leaves a thin black line on the special recording charts used. The slide wire wiper is carried on a drum which rotates with the lead screw, but which is made to follow the four turns of the slide wire by a much finer pitch lead screw, the accuracy of which is not critical. Connection to the wiper is made by a gold contact at the end of the gearbox shaft. The variables which it is intended to record will vary only slowly, so no particular attention has been paid to a short traverse time for the stylus : the stylus will make a full traverse in about forty seconds. The slide wire is a single strand of Nichrome wire with a gold contact rubbing on it. The great advantage of a slide wire of this type is that it is stepless ; there are, therefore, no difficulties from hunting however high the gain of the error amplifier, provided that overshoot of the motor is controlled.

The motor driving the rebalancing potentiometer is identical with the pen motor, except that a conventional miniature wire-wound potentiometer is coupled directly to the shaft.

The chart drive is constructed from an ordinary pocket watch movement which rotates the chart once in twelve hours. A cam rotating once per hour allows a pair of contacts to close for approximately ten seconds every quarter of an hour. The clock can be removed bodily from the side of the recorder case, the three locating pins also serving to carry current to the clock contacts. The pen excursion is 12mm and the chart is divided into ½mm divisions. The thickness of the line produced by the stylus is such that it is simple to estimate to a quarter of a division. In this way a resolution of at least 1 per cent of the full-scale excursion can be obtained.

It is thought that this recorder, illustrated on the left, may also be useful for non-biological applications such as meteorology and packaging research.



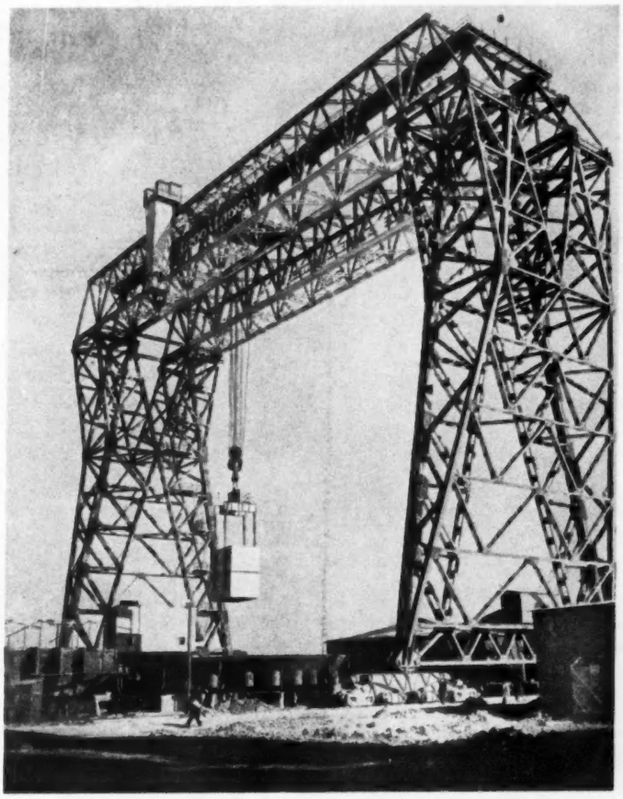
Miniature chart recorder : the transistor amplifier is at the far end of the case, beyond the amplifier balancing (left) and bridge balancing motors. The chart and drive are on the right : the signal enters at the blade terminal in the foreground

(To be concluded)

GENERAL ARRANGEMENT OF 200-TON GOLIATH CRANE

200-Ton Goliath Crane at Bradwell

In an article dealing with constructional progress at the nuclear power station being built at Bradwell for the Central Electricity Generating Board by the Nuclear Power Plant Company, which appeared in our issue of January 17 last, brief mention was made of the Goliath crane being installed for handling the very heavy boiler and reactor structures. This crane, which has now been completed and successfully undergone its acceptance trials, can be seen lifting a 200-ton block in the illustration on the right. It is designed to raise loads up to 200 tons on its main hook and 30 tons on an auxiliary hoist, and has a clear height of 140ft below the crab girder.



A GOLIATH crane, which has been installed at the site of the nuclear power station being built by the Nuclear Power Plant Company, Ltd., at Bradwell-on-Sea, Essex, is believed to be the largest equipment of its kind yet made. This crane was designed and built by Clyde Crane and Booth, Ltd., of Rodley, Leeds, and its associate company, Clarke Chapman and Co., Ltd., of Gateshead-on-Tyne, the sub-contractor for the steelwork being the Tees Side Bridge and Engineering Works, Ltd., of Middlesbrough. It is to be used for the lifting and placing of the very heavy boiler and reactor equipment, and its design and operation are such that it will permit civil engineering work on the reactor buildings to proceed uninterrupted whilst the heavy equipment is being handled. An impression of the duties the crane will be needed for is given when it is pointed out that in each of the reactor buildings there will be six 19ft diameter, 87ft high boilers, and a spherical steel pressure vessel 67ft diameter. These boiler shells, each weighing nearly 200 tons, will be floated by sea to the site from the factory of Head Wrightson and Co., Ltd., at Thornaby-on-Tees. The reactor pressure vessel, which weighs some 1100 tons, will be fabricated on site and handled in sections by the crane.

The general design of the crane can be seen in the drawing we reproduce opposite. It is of overhead girder construction supported at each end by a leg, each leg being mounted on eight four-wheeled bogies. The crane is designed for a horizontal wind load of 5 lb per square foot under the worst working conditions. With a centre distance of 178ft between the bogie rails and a clearance of 167ft between the legs, the crane completely straddles the reactor buildings, which are being built between the 1200ft length of standard gauge bogie tracks. The tracks on which the crane runs are carried on 7ft deep reinforced concrete continuous beams, which, in turn, are supported on closely pitched concrete piles. With this length of track the crane will be able to lift the ring segments of the pressure vessels from a site welding station towards one end of the site and deposit them in the reactors at the other end of the site. It will also take the complete boiler shells from a reception centre and place them in position, as well as carrying out other heavy equipment installation work within its operating area.

Leading Particulars of Goliath Crane

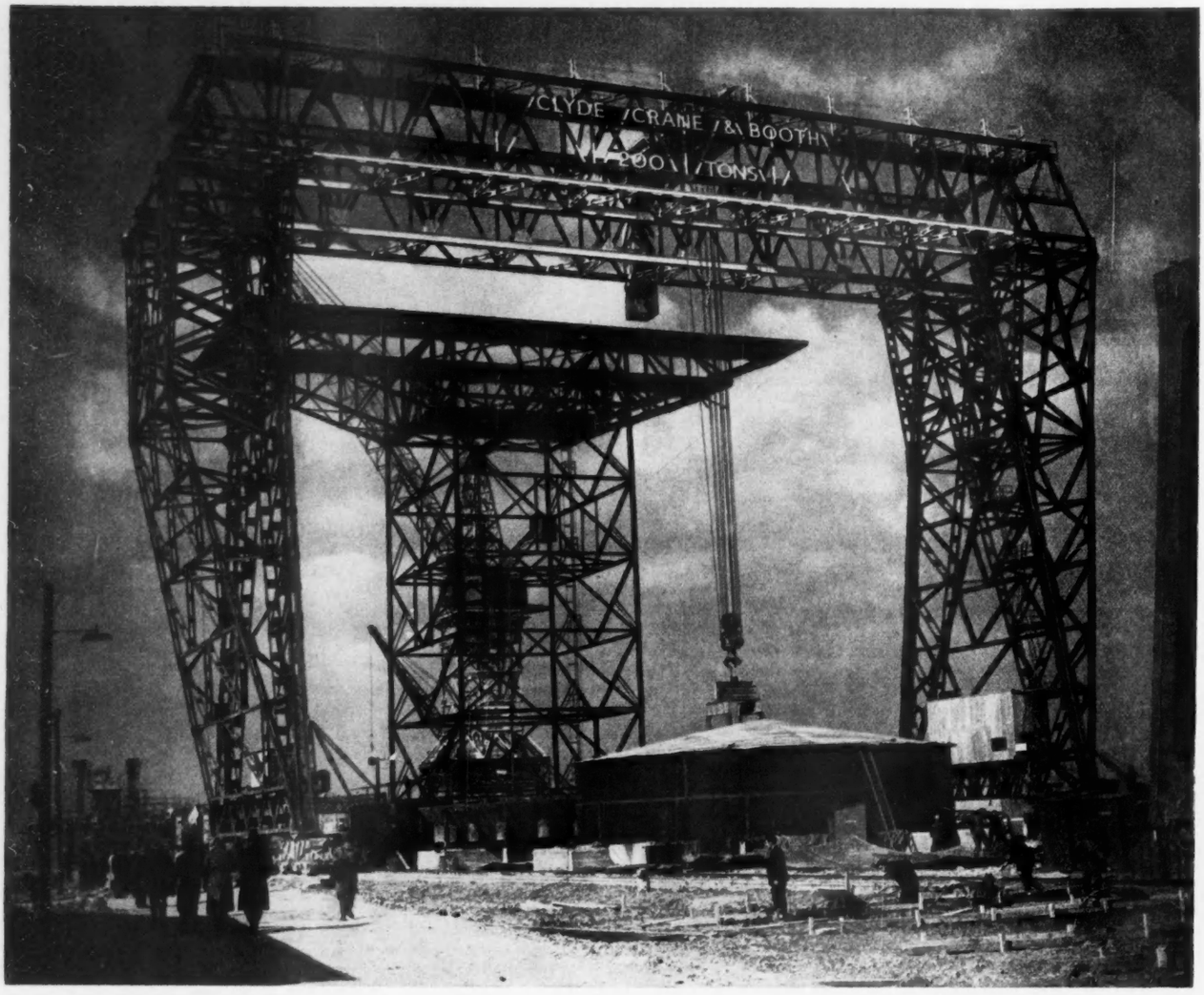
Main hoist :	
Maximum load	200 tons
Hoisting speed	4ft 9in per minute
Drive	Two 50 h.p. motors
Auxiliary hoist :	
Maximum load	30 tons
Hoisting speed	33ft per minute
Drive	Two 50 h.p. motors
Travelling :	
Track	1200ft long
Drive	Eight 20 h.p. motors
Speed (with 200-ton load)	50ft per minute
Track centres	178ft
Overall height of crane	177ft
Overall width of crane	226ft
Weight of crane structure	800 tons
Power supply (460V d.c.)	200kW diesel generator

The crane has a crab of conventional design which is mounted on rails along a pair of girders. As can be seen in the drawing, each of these main girder assemblies incorporates a complementary outrigger girder which imparts the required degree of lateral stiffness. These crab girders are supported at each end through legs of similar construction and the main vertical loads are taken through pin joints. One of the legs is anchored to the crab girder whilst the outer end of the other leg is left free with only a pin joint at the inner panel point. In effect, this arrangement makes the second leg a pendulum leg which, if required, can be rigidly coupled into the assembly. At its base each leg is pin jointed to the top equaliser beams of the bogies. Each top equaliser beam, of welded construction, transmits the load to two other equaliser beams which are coupled to the pairs of bogies through universal connections. By this arrangement the load is distributed over all the axles in each of the four bogies. The wheels and axles of the bogies are of standard railway construction and the axles run in phosphor bronze bushed bearings.

The front and rear axle in each bogie are driven through reduction and spur gearing by a 20 h.p. motor. Drive from each of the outermost axles is transmitted through side coupling rods to the mating axle on the same outer bogie. Thus, each eight-axle bogie has four driven axles. The eight 20 h.p. motors used for traction purposes give the crane a speed of up to 50ft per minute when carrying a load of 200 tons. Eight solenoid brakes are fitted to the travelling motion to hold the crane when at rest, normal braking being obtained by plugging through the control gear. In addition, storm clamps are provided to give further safety anchorage for the crane in gale conditions.

In order to keep the driver informed of the alignment of the two sets of track an indicator synchronised by a "Selsyn" control is provided in the cab. In the event of "skewing" of the legs provision is made for realignment by braking the bogies on one leg and separately driving those of the other leg. We are informed that up to the present there has been no need for realignment as the design of the drive, coupled with the rigidity of the structure, is such that the maximum skew experienced so far has been little more than 2in.

The crab assembly of the crane is fitted with conventional spur hoist gearing with the shafts running in ball and roller bearings. Barrels of steel tube construction are machine grooved and are arranged to coil the rope without overlapping; overwinding and overlowering switches are provided for both the main and the auxiliary hoists. The main hoist and the auxiliary hoist are each driven by two 50 h.p. motors, the main hoist being capable of raising 200 tons at 4ft 9in per minute and the auxiliary hoist 30 tons at 33ft per minute. The crab is traversed across the working area by two 20 h.p. motors at



Goliath crane with its erecting platform at the rear. A load of 200 tons is suspended from the main hoist

speeds of up to 50ft per minute when handling a 200-ton load. Each hoist is fitted with automatic solenoid braking and the speed of lowering is also controlled electrically. When power is off movement of the crab is prevented by two solenoid brakes, and during operation normal braking is by plugging through the controllers. Current is supplied to the crab through a pick-up gear situated on one side of the main assembly and making contact with bare cables carried on struts on one of the outrigger girders.

The driver's cab is supported from an extension on one side of the crab and is positioned below the level of the top girder assembly. From this cab the driver has a clear unobstructed view of the load, which is always immediately below and in front of him, and the whole of the working area. With the control gear fitted each motion is independently operated by means of a master reversing controller which operates magnetic contactor gear. The speed of lowering on each hoist is governed by potentiometer dynamic braking and the rating of the resistances is such that a full load can be lowered the full length of travel of the hook once per hour. All of the electrical control gear is carried on the crab structure and is readily accessible for inspection or maintenance purposes. We are informed that when raising the maximum load of 200 tons the deflection of the crab girders is of the order of $\frac{3}{4}$in at the centre.

When designing the crane it was considered desirable to make it completely independent of main power supplies, which would have involved the use of long trailing cables. Power is therefore supplied by a diesel generator set built in an enclosure on one of the crane legs. The Crossley 200kW diesel generator set used supplies current at 460V d.c. for all the crane motions.

The method of assembling the main crane structure is of interest in that it is built up of shop-assembled riveted mild steel sections. These units were assembled together on site with high-tensile bolts using torque wrenches to give a predetermined and controlled loading on the nuts. With this method of assembly there has been obtained a working structure which can readily be dismantled and re-erected for use on other sites. It is stated that the crane itself took some fourteen months to assemble, and for its erection the large working platform to be seen in the background of one of our illustrations was used in conjunction with the jib crane in the rear. This platform is now to be dismantled, whilst the jib crane, which runs on transverse rails across the main Goliath crane tracks, will continue in service as it can be run clear of the main crane area when necessary. It is estimated that the crane can, when finished with, be dismantled in under six months without interfering in any way with the normal working of the station. Its availability during the building of the station is thought to have made possible a reduction of some six months in the overall construction time which would have been required. Furthermore, had conventional lifting equipment been used wider spacing would have been required between the main structures in the power plant.

Heavy-Duty Compactor

A COMPACTING machine known as the " Vibro-Tamper " is now being imported into this country from the United States by Roadways Equipment (1938), Ltd., 232–242, Vauxhall Bridge Road, London, S.W.1. The machine consists of a welded frame mounted on crawler tracks and carrying at the front six vibrating shoes. The shoes are attached to the frame by articulated links. Each shoe is 240 square inches in area and has a double vibrator unit driven from the main engine through V-belts, the vibration having a frequency of 2000 to 2200 r.p.m., with an amplitude of approximately $\frac{1}{4}$in. The crawler tracks are driven from the 75 h.p. engine via hydraulic pump and motor; speeds range between 14ft a minute and $1\frac{1}{2}$ m.p.h. The compacting width is 12ft 6in with six shoes, 13ft 2in with extensions, or 8ft 6in with two shoes removed.

Failure of a 60MW Steam Turbo-Generator

By A. L. G. LINDLEY, M.I.Mech.E.,* and F. H. S. BROWN, B.Sc., M.I.Mech.E., M.I.E.E.†

No. I

Details of investigations into the failure of a 60MW steam turbo-generator at Uskmouth power station on January 18, 1956 were given in a paper discussed at the Institution of Mechanical Engineers, London, on March 21, 1958. The paper showed that the catastrophe resulted from failure of the governor and emergency protective devices after the exciter had been inadvertently tripped; this failure was traced to the presence of black oxide of iron in the oil system and the way it built up on the working surfaces of pistons and cylinders. Overspeeding of at least 70 per cent followed, causing disintegration of the l.p. turbine and the generator. Abstracts from the paper are given here.

ON January 18, 1956, a catastrophic accident occurred to the No. 5 60MW turbo-generator in the Uskmouth Power Station of the Central Electricity Authority in which two men lost their lives and nine other persons were injured. The set first went into service on November 21, 1955, and at the time of the accident had been in operational service for a little less than eight weeks. A general view of an identical machine is shown in Fig. 1.

The turbo plant in the station comprises six 60MW units arranged in line. They operate at steam inlet conditions of 900 lb per square inch gauge 900 deg. Fah., with a designed vacuum at continuous maximum rating of 28·9in of mercury and running speed 3000 r.p.m. There are five stages of feed-heating giving a final temperature of 385 deg. Fah.

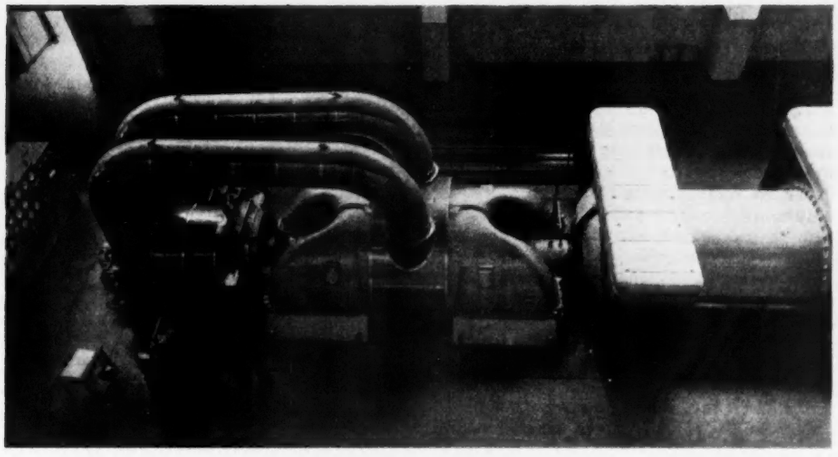


Fig. 1—60MW turbo-generator

The turbines are of two-casing design and the high-pressure rotor is rigidly coupled to the double-flow low-pressure rotor which is in turn rigidly coupled to the generator. All turbine rotors are of built-up construction employing shrunk-on discs.

The high-pressure casing is built up from steel castings and the low-pressure casing is made entirely from iron castings. The exhaust casings are supported by side feet which rest on steel longitudinal girders spanning the twin condenser shells with an intermediate supporting column.

High-pressure steam is supplied through twin pipes each connected to an emergency valve chest, one on either side of the high-pressure casing. From the emergency valves, steam passes through four flexible loop pipes to the governing-valve chests, which are cast integral with the top and bottom halves of the high-pressure casing.

There are four governing valves arranged symmetrically, two at the top and two at the bottom of the high-pressure casing, working in unison and admitting steam to a continuous belt in the high-pressure casing upstream of the nozzles of the first stage. All these valves are operated by oil relays of single-acting type with spring closure. The centrifugal speed governor operates the primary governing relay which transmits motion to the secondary relays operating governing and emergency valves through a system of layshafts. The usual emergency overspeed protection is provided, this governor being of twin bolt type. Its action, in common with the action of the other emergency protective devices, shuts off the oil supply to all relays and connects the supply to drain, which would normally result in closure of all valves.

The generator is of the orthodox totally enclosed revolving field type, cooled by hydrogen at a normal presure of 0·5 lb per square inch gauge. It has a maximum continuous rating of 60,000kW at 0·8 power factor lagging, 75,000kVA at 3000 r.p.m. and generates at 11·8kV, three-phase, 50 cycles. The rotor is made from a solid forging and the end turns of the winding are held radially by shrunk-on end rings. The gas-tight stator casing is designed with sufficient robustness to withstand explosion of a hydrogen-air mixture.

Each unit is provided with a motor-driven exciter set comprising main and pilot exciters and incorporating a flywheel capable of storing sufficient kinetic energy to maintain full excitation for a period of 0·3 second following failure of power supply to the exciter driving motor.

Operating Conditions Immediately Prior to Accident

At the time of the mishap, set 5 had been in continuous operation at a nominal load of 60MW for 60 hours. The logged readings of gauge-board instruments, supervisory gear &c., showed no abnormality or unusual deviation. Sets 1–4, which had been in service for a considerably longer period than set 5, were also on load at the time whilst erection work on set 6 was nearing completion. The motor-driven exciter set of machine 6 was undergoing test and a stage had been reached when it was decided to close down for adjustment.

The control panels for the exciter sets for units 5 and 6 were adjacent to one another and exciter 5 was inadvertently tripped instead of 6. This action automatically energised the main tripping relay of set 5, thus opening the 132kV air circuit-breaker, the unit transformer 3·3kV oil circuit-breaker, and generator field switch. The solenoid trip on the turbine, designed to shut all steam valves, was also energised so that if the normal sequence of events had taken place, there would have been sudden rejection of full load accompanied by a transient speed rise not exceeding about 7 per cent above normal. In this instance, however, signs of distress on the machine were evident, and in a few seconds the low-pressure turbine disintegrated and the whole machine was wrecked.

Circumstances Immediately Following the Accident

In view of the sudden onset of the disaster and the severity of the damage, it is not surprising that there was lack of accurate observation regarding the behaviour of the machine during the few seconds between normal running and final disintegration. An analysis of statements taken from many people near the set, including the erection crew working on set 6, seemed to indicate that a few seconds after tripping there was a minor explosion accompanied by vibration, followed by a major explosion which appeared to coincide with the disintegration of the low-pressure turbine and the break-up of the generator rotor.

Hydrogen escaping from the generator rose in the form of a burning cloud and a small fire broke out in the generator windings, but the main fire protection system was not called into use, since the oil spilled from the system did not ignite and the oil feed to it was very promptly shut off.

The most serious aspect of the accident was that two men lost their lives, one of whom was the turbine driver, and nine men were injured.

Preliminary Survey of the Damage.—The low-pressure turbine casing was shattered and fragments were scattered over the turbine room (Fig. 2). The low-pressure turbine shaft was broken into a number of pieces, wheels, couplings, and pieces of shaft having been projected away from the set with considerable force, causing damage to the turbine house roof, walls, and crane rails. The No. 5 low-pressure wheel from

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Fig. 2—General view of damage to turbo-generator at Uskmouth

the generator end came to rest in the river bank 150 yards from the set, and a 10in diameter atmospheric exhaust pipe was cut through by the No. 3 low-pressure wheel adjacent to the high-pressure turbine. Although devoid of blades and otherwise damaged, eleven wheels were intact, but of the last (No. 6B, low-pressure) stage wheel adjacent to the generator only a few rim fragments were found at first.

The high-pressure turbine spindle had broken off just inside the gland at the end of the casing adjacent to the low-pressure turbine. The whole cylinder had moved a few inches axially away from the low-pressure turbine, the support at one end having been lost as a result of the fracture of the low-pressure turbine casing, whilst the governor bearing pedestal and relays were considerably damaged. The high-pressure casing was, however, intact.

The generator rotor was shattered, but most of the fragments were contained within the stator, although this was badly damaged as shown in Fig. 3. A portion of the bursting rotor had penetrated the full depth of the stator laminations and was projecting from the outer shell.

The stator end covers had been forced outward and the outer bearing pedestal shattered. The rotor end turn support-ring at the turbine end had split axially and opened out whilst that at the slip-ring end had split into two pieces. The shaft extension carrying the slip-rings and barring wheel had become detached from the rotor and was thrown beyond No. 6 set. The turbine emergency and governing valves were all in closed positions after the accident and no marked escape of steam occurred at any time.

The tripping of the exciter motor and the consequent tripping of the unit transformer 3·3kV O.C.B. cut off the power supply to the turbine supervisory equipment and speed recorder. The latter indicated a speed rise from 2970 to 3045 r.p.m. up to the time when the record terminated, this being less than the anticipated transient speed rise corresponding to rejection of full load.

Subsequent Work of Investigation

The damage to the machine and its components as a result of this disaster was so extensive that at the start of the investigation it was by no means certain that sufficient evidence could ever be drawn from the reassembled wreckage or history of the event to permit firm conclusions as to the ultimate cause being drawn. It was clear that every facet would require the most detailed investigation, and it was for this reason that a working party, including a wide diversity of interests and skills, was at once set up. This working party decided at the outset that investigation must proceed cautiously and that no hasty conclusions should be drawn.

The closure of all steam valves and lack of escaping steam after the accident were definite contra-indications of excessive overspeed, and it was at first suspected that a flaw in material might have caused failure at a speed only a little above normal. For this reason, and in order that all possible deductions could be drawn from examination of the broken parts before the inevitable processes of corrosion masked any information, attention was first concentrated on detailed metallurgical examination.

Subsequent investigations were able to prove beyond all doubt that the unit as a whole had in fact attained an overspeed of the order of 70 per cent above normal before final failure, and, although the metallurgical examinations were pressed through to what proved to be a satisfactory conclusion, exonerating all components of weakness, attention was then concentrated upon the governing and emergency protective devices, and it was found possible to establish the mechanism of failure and the sequence of subsequent events with some precision. The reasons for failure centre on the presence of black iron oxide in the oil system and the way in which it built up on working surfaces of pistons and cylinder bores.

The build-up of black iron oxide in the form of films capable of seizing power pistons had not been encountered previously, and, although retrospective examination showed that some warning was given by deterioration of governing performance, this was at the time not unnaturally construed as a transitory stickiness in operation and there was no realisation of how rapidly a dangerous state could be achieved.

The formation of black iron oxide of very small particle size has been shown to be due to slight contamination of the oil by brackish water, coupled with abnormally long shut-down periods. This phenomenon is also believed to be unique, and its discovery has placed added emphasis on the necessity of actively investigating any observed abnormality in the performance of turbine control and protective devices, and provides further justification for the effort expended in recent years in the development of designs which permit the comprehensive testing while on load of all such devices.

The paper presents in ordered sequence the conclusions finally reached as a result of the investigations, but the descriptions of the actual work and evidence leading thereto are necessarily brief. Inevitably in an investigation of this nature, with no prior indication of the conclusions which might ultimately be reached, many possibilities were explored which later turned out to be blind alleys, of no interest in the final result except in so far as no facts conflicting with the findings here recorded were discovered.

Detailed Investigations.—It was clear from a preliminary survey of all that was known immediately after the accident that its cause could not be readily ascertained and that the investigation would have to cover a very wide field and might be prolonged. A meeting was therefore immediately called at which all the main interested parties were represented, and a committee of investigation was set up consisting of expert representatives of the makers with some of their sub-contractors and the C.E.A., and upon which representatives of Lloyd's Register and the metallurgical section of the N.P.L. also consented to sit. The task of co-ordinating the necessary investigations was delegated to this committee on the understanding that other interested parties should have unrestricted access to their findings and to the evidence upon which they were based.

All available information was gathered together and recorded. This included eye-witness accounts, records of positions of fragments and reports of operational history especially those pertaining to the period immediately prior to the breakdown. A comprehensive programme of photographing parts during removal and dismantling was undertaken and all fragments of rotating parts were returned to the maker's works, where they were reassembled in their normally correct relative positions to facilitate study of the mechanism of breakdown. Metallurgical examination of rotating parts was carried out and all fracture surfaces were examined for flaws. An independent recalculation of stresses in all rotating parts was also made.

Important factors which emerged fairly quickly were as follows :

(1) Eye-witness accounts appeared to indicate a time interval of about eight to thirteen seconds between load rejection and break-up.

(2) All tripping circuits designed to be set in motion by tripping of the exciter were found to be in order.

(3) The turbine emergency valves and their operating relays were found to operate satisfactorily.

(4) Damage had occurred to parts of the governing and emergency equipment of the turbine and, although positions of certain parts were abnormal, these appeared to be the result of the accident.

(5) An analysis of statements by all those who were near the set at the time established that no major escape of steam occurred and although there were various references to change of note, those relatively close to the set did not consider that an exceptionally high speed was attained.

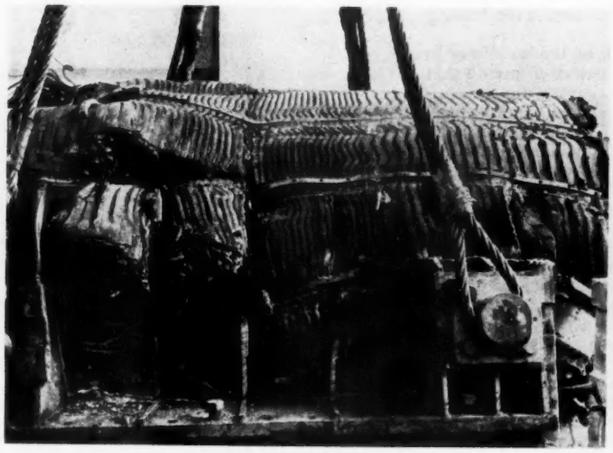


Fig. 3—Damage to stator showing penetration by fragment of rotor

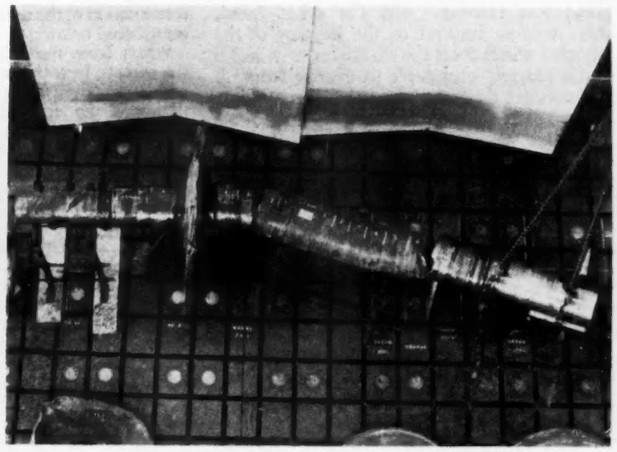


Fig. 4—Assembly of pieces of low-pressure shaft

Early examination of all fracture surfaces revealed no obvious flaw except in the case of the generator rotor, in which a small fatigue crack at a point under the turbine end fan-ring appeared to be the origin of the system of brittle fracture which had propagated during break-up of the rotor.

With one exception, all twelve wheels of the low-pressure rotor had become detached and the shaft had broken into four pieces. One wheel remained on a short length of shaft and was found outside the station.

Fig. 4 shows an assembly of the pieces of shaft which gives some idea of the bending which took place at the time of breaking-up. The sixth-stage wheel on the generator side was missing except that fragments of the rim were found with blade roots attached. Of the eleven low-pressure wheels which remained whole, all the blades had become detached.

It was clearly important to know whether the missing wheel was substantially whole or had broken up completely as suggested by the rim fragments. After many days of patient search, a small fragment of the hub was found which indicated that the wheel had in fact burst.

The deformation of this fragment was remarkable, the principal features being a contraction of about 14 per cent at the bore parallel to the axis of rotation, diminishing rapidly at points more distant radially from the wheel centre, and a marked concave curvature at the bore.

It was deduced that the observed deformation could have been produced only if the wheel first split along a radius and then opened up to a C shape due to centrifugal force, the axial contraction being the result of the high tangential tension and the curvature at the bore being due to the well-known phenomenon of "anticlastic curvature." Calculations showed that stresses of sufficient magnitude could exist in a split wheel even at normal speed.

In course of time, many other fragments were discovered including a large piece from the hub, which was buried in the condenser tubes. This large piece confirmed the deductions made from the earlier fragment regarding the mode of break-up, and it became evident that a brittle type of fracture started near the keyway and proceeded outward in a roughly radial direction, followed by opening up of the wheel to a C formation with marked plastic deformation opposite the keyway.

The rim in this region was subjected to compression during the process and failure occurred in shear along a series of spiral paths, resulting in the curious fracture systems shown in Fig. 5, which illustrates an assembly of all that has been recovered of this wheel.

That small part of the bore which had not suffered plastic deformation due to the opening up process did not appear to have stretched, but this was purely negative evidence since overspeeds exceeding 63 per cent would be necessary to initiate any such stretching, and deformation measurable on the small piece available would have necessitated an even higher speed. The bores of the other low-pressure wheels had been deformed in a conical fashion due to rolling against the shaft under the action of tremendous gyroscopic moments. All the wheels were in fact badly mutilated, making measurement of deformation extremely difficult.

Much other evidence was being tabulated at this time and it became possible to survey a number of factors which could be grouped together for study. For example, the key belonging to the No. 6B low-pressure wheel was found whole and almost undamaged but the keys belonging to the remaining eleven low-pressure wheels had all either sheared in half or become badly mutilated. It was also known that one of the fractures in the low-pressure shaft had occurred almost in the middle of the seat of the broken wheel and a fragment of the shaft at this

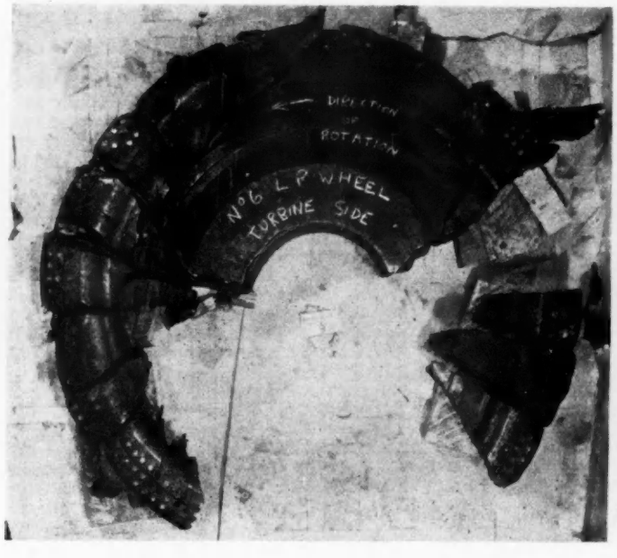


Fig. 5—Assembly of fragments of 6B low-pressure wheel

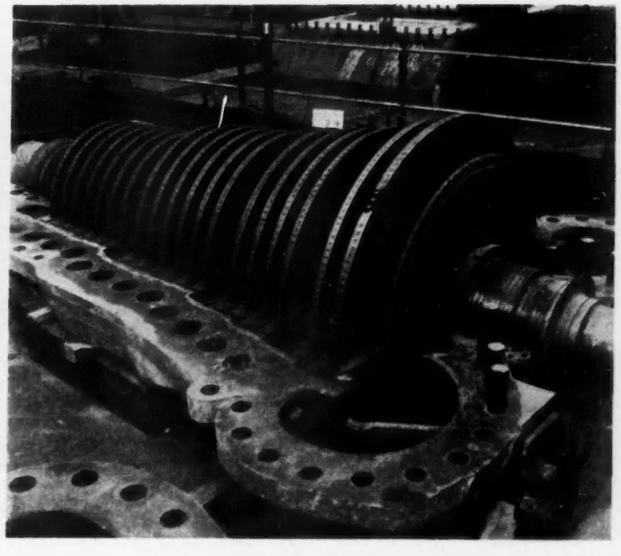


Fig. 6—Condition of high-pressure rotor

point was missing. On the other hand, there was an imprint of the keyway of the adjacent wheel 5 on the shaft seat of wheel 6 and it seemed reasonable to deduce from all this evidence that wheel 6 had broken up while the remainder of the rotor was still intact.

At this stage, no clear evidence of undue overspeeding was apparent on the low-pressure and generator rotors, and no special significance could be attached to the bursting of wheel 6.

One of the crane columns and a section of the girder under the crane rail at one side of the turbine room had been damaged by flying fragments and it was not possible to place the crane over the high-pressure casing for some time. On this account the opening of the high-pressure casing for examination was delayed considerably.

As mentioned earlier, the high-pressure shaft had broken off at a point just inside the gland at the high-pressure end. The appearance of this fracture was that of the rotor overtaking the coupling. It was expected that the high-pressure rotor would be damaged very considerably in view of the loss of support of casing and rotor at the end adjacent to the low-pressure turbine, and it was a surprise to find it comparatively undamaged, as shown in Fig. 6.

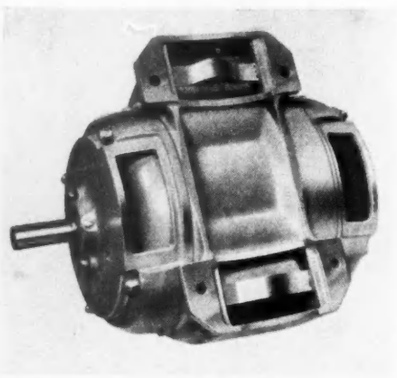
(To be continued)

Improved Single-Phase Motor

A NEW range of induction motors specifically designed for single-phase duty has been introduced by Newman Industries, Ltd., Yate, Bristol. This motor is an enclosed drip-proof, capacitor-start, induction-run motor, in which the most obvious improvement is that the capacitors for starting are housed in the hollow feet of the motor carcase, where they are held in position by spring clips, as illustrated here. This arrangement eliminates the excrescence usually presented by the condenser enclosure mounted on the motor frame. In addition to the mechanical protection afforded by the motor frame in the new Newman motor, each condenser is completely enclosed in an aluminium canister which, in turn, is protected against moisture by an insulating case.

At present, this motor is available in the following sizes :—1, 1½, 2 and 3 h.p., four-pole, for single-phase supplies at 50 c/s or 60 c/s. Ultimately, however, it is proposed to extend the range to cover ½ h.p. to 5 h.p. in two-pole, four-pole and six-pole speeds (that is, 3000 r.p.m., 1500 r.p.m. and 1000 r.p.m., respectively, at 50 c/s). The performance of the existing range is summarised in the accompanying table and the construction of the motor is shown in the drawing reproduced below.

Apart from the location of the capacitors in the carcase feet, the main points of interest that will be apparent from the drawing are the positioning of the terminal block and the centrifugal switch inside the non-drive-end bracket. A totally enclosed dust-tight moulding houses the static part of the switch, the contacts being of silver. The rotating part of the switch consists of interlocking pressings without any hinge pins or similar parts that may be subject to seizing. This rotating part of the switch is shrouded by the fan and thus protected from any dust that may be drawn in by the cooling air, the path of which is indicated roughly by the arrows in the drawing. Air is drawn in at the underside of the drive-end bracket, passed axially through the motor and exhausted at the underside of the non-drive-end bracket. A pressed steel baffle is arranged to expel the air from the motor in front of the fan and through the exhaust at the underside of the non-drive-end bracket. Both end brackets can be turned through 180 deg. so that the air vents are still at the bottom of the motor when it is ceiling mounted. The non-drive-end bracket is so designed that it can be supplied with the conduit entry on the right or left-hand side of the motor. A cover plate on the face of the end bracket gives direct access to the moulded terminal block and stud type terminals. Terminal markings are permanently engraved. Provision is also made in the end bracket casting to accommodate a thermal overload protective device (which may be auto or manual reset) when required. Dimensionally, the motor is to NEMA (American) standards. The bearings are standard metric sizes and are lightly preloaded to ensure quiet vibration-free running. In common with all Newman motors every rotor is dynamically balanced.



The motor inverted to show the condensers held by spring clips in the hollow feet of the frame

Performance Data for "DK" Drip-Proof Single-Phase, Squirrel Cage, Capacitor Start Motors

New NEMA frame dimensions. Continuous ratings ; 480V maximum ; Class-A insulation ; temperature rise 40 deg. Cent.

50 c/s to B.S. 168

H.P.	F.L. r.p.m.	Line current, F.L. 230V	Efficiency			P.F.			Torque, per cent F.L.		Locked rotor (starting) current at 230V	NEMA frame	Maker's reference
			F.L.	¾ L	½ L	F.L.	¾ L	½ L	Locked rotor	Breakdown			
1	1440	6·6	70	70	62	0·70	0·64	0·53	220	230	34	182	DK1542-B
1½	1440	9·5	73	72	66	0·70	0·63	0·54	250	250	43	184	DK1572-B
2	1435	11·1	78	77	72	0·75	0·67	0·57	240	260	55	213	DK1842-B
3	1435	17·0	80	79	75	0·72	0·65	0·54	250	220	83	215	DK1872-B

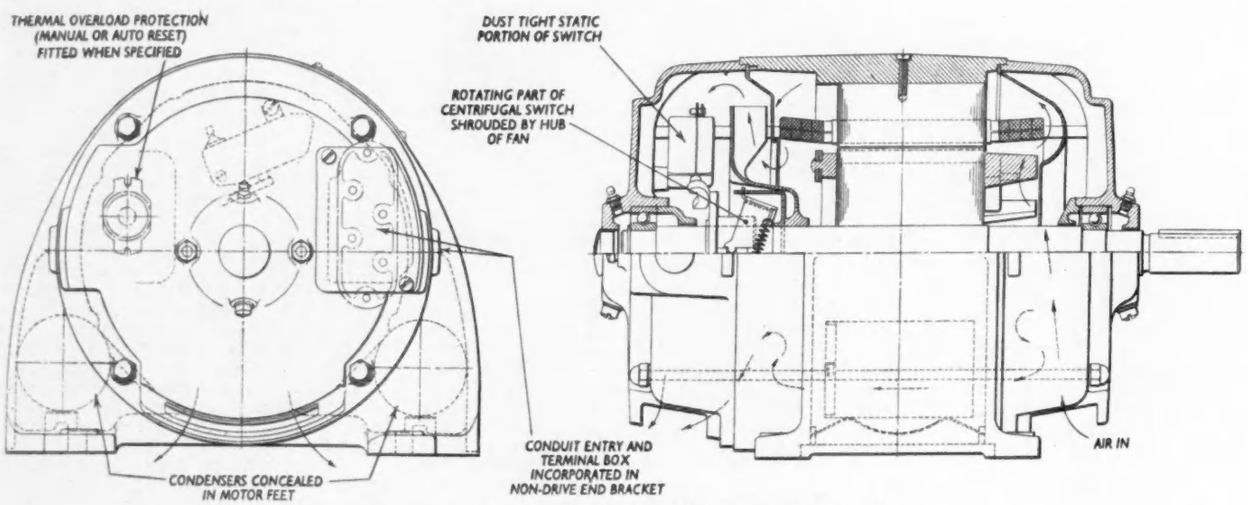
60 c/s to NEMA Standard MG. 1, Design "L"

H.P.	F.L. r.p.m.	Line current F.L. 230V	Efficiency			P.F.			Torque, per cent F.L.		Locked rotor (starting) current at 230V	Code letter	NEMA frame	Maker's reference
			F.L.	¾ L	½ L	F.L.	¾ L	½ L	Locked rotor	Breakdown				
1	1750	6·6	74	73	67	0·67	0·60	0·50	300	240	35	K	182	DK1542-B
1½	1740	9·4	74	74	68	0·70	0·63	0·53	330	260	50	J	184	DK1572-B
2	1740	11·3	76	76	70	0·76	0·68	0·57	340	270	65	J	213	DK1842-B
3	1740	17·1	78	77	72	0·73	0·65	0·55	310	240	90	H	215	DK1872-B

Notes :

60 c/s motors, service factor : With voltage and frequency at the values shown on the nameplate, the motors can be overloaded up to the horsepower value obtained by multiplying the rated output by the service factor in accordance with NEMA Standard MG.1. The service factor shown on the motor nameplate is 1·25 for ½, ¾ and 1 h.p.; 1·2 for 1½ and 2 h.p.; 1·15 for 3 h.p. and larger.

60 c/s motors, code letter : The code letter which is shown on the motor nameplate indicates the locked rotor kilovolt amperes per horsepower in accordance with NEMA Standard MG.1.


THERMAL OVERLOAD PROTECTION (MANUAL OR AUTO RESET) FITTED WHEN SPECIFIED
DUST TIGHT STATIC PORTION OF SWITCH
ROTATING PART OF CENTRIFUGAL SWITCH SHROUDED BY HUB OF FAN
CONDENSERS CONCEALED IN MOTOR FEET
CONDUIT ENTRY AND TERMINAL BOX INCORPORATED IN NON-DRIVE END BRACKET
AIR IN

Simplified general assembly drawing of Newman single-phase motor

SHORTER REPORTS

Road Schemes

THE Government's road programme has been in the news a good deal over the past two or three months, and announcements of new schemes, or progress reports of those already under construction, have been coming from the Ministry of Transport and Civil Aviation one after the other. We have three such announcements to record in this week's issue, namely, a proposal for an urban motorway through the western outskirts of London, the award of a contract for the Maidstone by-pass, and the start of work on the London/Birmingham motorway.

WEST LONDON MOTORWAY

Proposals for an elevated roadway starting near Chiswick flyover and continuing to a point near Boston Manor Road, Brentford, were announced by the Ministry on March 18. The proposals exist in outline only at present, and Sir Alexander Gibb and Partners have been appointed consultants for the scheme. It is the first urban motorway in the Government's plans and has been described as "the most imaginative piece of road planning to come from a British Government in living memory." The following information about the proposal has been divulged by the Ministry.

The Minister has adopted this plan—the first of its kind in the country—to avoid the demolition of property which would have been involved in the original proposal in the Middlesex county development plan for an entirely new western exit at ground level. The upper deck of this two-tier road will be part of the London–South Wales motorway and for the first mile of its route the motorway will follow the line of the Great West Road. Single supporting piers with splayed heads will be erected along the centre strip of the Great West Road, allowing traffic to pass freely along the dual carriageways on either side. Where the two roads diverge, the motorway, still on viaduct, will swing in a north-westerly direction to pass over a large factory and then descend gradually to ground level. The total length of the viaduct will be 1½ miles.

Westwards from this point the motorway will continue at ground level, following the line shown on the development plan from Osterley Park as far as the junction with the proposed Slough-Maidenhead by-pass, which is the limit of the present scheme. This part of the motorway will form a fast new route for the rapidly expanding road traffic to and from London Airport. Direct connection with London Airport will be provided by a spur road. The length of new road construction involved is about 12½ miles of which 1 mile is for the airport link. The Minister will consider the comments of local authorities before publishing a draft scheme under the Special Roads Act to establish the line of the motorway. There will be the usual statutory period for lodging objections to the draft scheme after it has been advertised, probably in the early summer.

Both the motorway and airport link will have dual 24ft carriageways and will be designed for high speeds. Where the motorway is on viaduct there will be a 4ft central reservation and an overall width of 60ft. With the exception of an interchange point on the Great West Road near Lionel Road, there will be no access to the motorway from existing roads until it reaches Cranford Parkway (Route A.312), where a flyover junction with link roads will be built. Cranford Parkway is on the line of the proposed "D" ring road. Provision will also be made for a flyover at the junction with the proposed North Orbital Road at Richings Park, and the spur road to London Airport will be linked to the motorway by a flyover junction. At the western end of this scheme there will be link roads to a surface roundabout on the Bath Road (A.4), but the motorway will be continued over the top of the roundabout on a flyover to connect with the Slough-Maidenhead by-pass.

West of the viaduct the scheme will involve the construction of twenty-nine bridges, ten of which will carry the motorway over waterways, three over or under railways, and eleven over or under secondary roads. The other five bridges will be at flyover junctions. The viaduct will be designed to carry full standard loading. This means in effect that it will be for the use of all motor vehicles except articulated vehicles carrying abnormal loads. The average height of the viaduct will be about 25ft, but where it passes over a factory at its western end it may rise as high as 65ft.

MAIDSTONE BY-PASS

A contract for the first section of the Maidstone by-pass, over 5 miles long, between the Chatham Road A.229 north of Maidstone and a point on A.20 near Hollingbourne at the eastern end, has been let to Richard Costain, Ltd.; the total cost of the scheme will be about £1,500,000 and work is due to start next month. While work on this length is proceeding, a further contract will be let for the continuation of the by-pass westwards, which will include a flyover junction at the Chatham Road crossing and a new bridge over the River Medway.

The Maidstone by-pass will be constructed to motorway standards with twin 24ft carriageways. Except for links with the Chatham Road and the Sittingbourne Road A.249, there will be no connections with side roads. Besides the flyover junction at the Chatham Road crossing, other flyover junctions will be built at the Sittingbourne Road intersection and at the eastern end of the by-pass where it joins A.20. There will be eight major bridges on the first section of the by-pass and five more on the second section.

Traffic congestion at the crossing of the Medway and in the narrow streets of Maidstone has been a serious problem for some years. The 1954 traffic census showed nearly 23,000 vehicles a day crossing the bridge over the River Medway. The scheme for the first section, except for the bridges, has been designed by the Kent County Council (the county surveyor is Mr. E. W. H. Vallis, M.I.Mun.E., F.R.I.C.S.) on behalf of the Minister. Messrs. Scott and Wilson, Kirkpatrick and Partners, consulting engineers, are responsible for the bridges. Eventually, the new road will be extended still further westwards to by-pass Ditton, Larkfield and West Malling.

LONDON-BIRMINGHAM MOTORWAY

Work was inaugurated on March 24 on the London-Birmingham motorway and its southern extension the St. Albans by-pass motorway. This scheme is unprecedented in size and speed of construction in this country. The inaugural ceremony was near Luton Hoo, in Hertfordshire, and was performed by the Minister, Mr. Watkinson, whose speech included the following points.

"I am here to-day," he said, "to start work on the largest single road scheme ever commissioned in this country. It will provide for the motorist close on 70 miles of new double track road built to the highest standards in the world to-day. Although there will only be nine intermediate connections with the rest of our road network, there will be no less than 200 flyovers and flyunders of one kind and another to be constructed. There will be over 12,000,000 cubic yards of earth to shift. This is the measure of an operation that will transform travel by road and provide Britain's first major motorway. Amenity has not been forgotten and I am confident that this will be not only one of the best roads in the world but one of the most attractive. The work which I start here to-day on behalf of the Government will therefore stand comparison with any road scheme anywhere else in the world.

"And yet this motor road between London and Birmingham is going to be built in nineteen months. If we were constructing it across virgin prairie this might not perhaps be so remarkable. But we are driving it through the heart of this small, densely populated and highly developed island. It is the greatest credit to our civil engineering industry and to the contractors concerned that the time scale which I set for this road has been accepted."

The significance of the scheme has been commented upon several times in these columns, most recently in our issue of January 24 last, on the occasion when the main contracts were let; some facts and figures in the design of the road were then given.

The firms involved are, for the 53 miles of the London/Birmingham motorway itself and 17 miles of diversioning roads, contractor John Laing and Son, Ltd., consultants Sir Owen Williams and Partners. For the 12 miles of the St. Albans by-pass motorway the same consultants are responsible for thirteen of the bridges, the county surveyor of Hertfordshire, Mr. C. H. ffolliott, directing the rest of the scheme; the contractor is Tarmac (Civil Engineering), Ltd. The estimated cost of all the work inaugurated on March 24 is £20,000,000, and the construction time allowed is nineteen months.

It will be appreciated that a major effort in planning and mechanisation has been made to achieve this short construction time. Three thousand seven hundred men and more than 1000 major pieces of road-making equipment will be used when work is at its peak. Two aircraft will be operated for supervision and for bringing spares for machinery. Some 4,000,000 square yards of roadway will be laid. There will be 150 bridges and a 575ft viaduct over the River Nene, Northamptonshire, and 450ft viaducts over the Great Ouse and the River Ousel, Buckinghamshire.

Cadmium-Sulphide Photo-Electric Cell

A NEW photo-electric cell embodying a specially constructed element of cadmium-sulphide has been introduced by Mullard, Ltd., Mullard House, Torrington Place, London, W.C.1. It is stated to be about 20,000 times more sensitive than the conventional photo-emissive cell, so that, under the influence even of very weak sources of light, it can produce enough current to operate a large relay directly and without intermediate amplification. The special form of construction consists of an interdigital pattern of copper strips whereby the resistance of the cadmium-sulphide element is reduced to such a point that the cell can produce the current necessary to operate a relay, with only a very small applied voltage. The cells are mounted on standard valve bases identical with those of the present Mullard range of conventional cells. Thus, when existing equipments are modified special head mountings or probes designed for specific installations can be retained.

The cadmium-sulphide cell can replace the conventional photo-emissive cells in the majority of industrial devices designed to perform on-off switching operations at speeds up to about 50 c/s and, being non-polar, it will operate from both a.c. and d.c. supplies. It offers particular advantage in flame-failure detectors for oil-fired burners—a field where photo-cells are very widely used—since its spectral response is greatest in the yellow/red region.

Typical performance figures for a Mullard cadmium-sulphide cell with a photo-cathode of 1·8 square centimetre effective area can be summarised as follows. From an illumination of 5ft-lamberts, with a colour temperature of 1500 deg. K, the cell will produce approximately 20mA for an applied voltage of 10V. From

the same illumination, but with a temperature of 2700 deg. K, the current is approximately 6mA. Within the limits of permissible power dissipation doubling the applied voltage gives a four-fold increase in current. Maximum dissipation is 1W at 25 deg. Cent. and 200mW at 75 deg. Cent. Dark current is extremely low : with 300V applied to the cell it is not greater than 2·5 microamperes at 25 deg. Cent. Spectral response range is 4500Å to 8000Å, covering the entire visible spectrum and extending into the near infra red, with maximum response in the yellow/red region.

A range of cadmium-sulphide cells will, in due course, be marketed by the Communications and Industrial Valve Department of Mullard, Ltd. They will include cells of various power handling capabilities, with photo-cathodes ranging in area from a few square millimetres to several square centimetres. Sample quantities will begin to be available in March, and quantity production of the first types is scheduled to start in May of this year. Conventional photo-cells will continue to be produced in quantity and will be available for production and maintenance of existing equipments and for applications where the cadmium-sulphide cell is not suitable, for example, where high operating speeds are involved.

Floating Containers for Use on Narrow Canals

AN experimental floating container has been evolved by British Waterways for freight traffic over 100 miles of narrow waterways in the industrial Midlands. This container, which has been developed from the compartment boat system of container " trains " which has proved so successful on the wide waterways in the West Riding of Yorkshire, is intended to carry loads which cannot be handled economically by the 25-ton narrow boat. It can be towed by a tug either singly or with others, as shown in the illustration, and can be lifted easily from the water by crane or slipway direct to loading or unloading points, or to a trailer or other vehicle.

There is at present in the Midlands a considerable volume of short-haul traffic passing in small quantities between canal-connected premises, and for traffic of this kind the floating container system is thought to have real advantages. The need for a high standard of packing is eliminated, it is claimed, and there is a high degree of immunity from loss or damage, and the costs of loading, stowing and unloading are minimised. Five prototype containers—three 7ft long, one 10ft and one 17ft, with capacities of 3, 5 and 8 tons, respectively, and all of 7ft beam, to allow passage through the locks of narrow waterways—are being demonstrated at the British Waterways Sampson Road Depot in Birmingham. These prototypes are of plywood construction, but it is envisaged that production containers would be constructed of either "Fibreglass" or aluminium with bracing and ribbing moulded into the craft to make a light, but strong, unit. Watertight doors, designed to open outwards, would give easy access. Towing attachments which slide in slotted tubes to the full depth of the containers allow individual containers in a " train " to be loaded to different depths, and also prevent rolling and turning.

Chemical Engineers

THE Institution of Chemical Engineers has recently surveyed the situation concerning the present and future supply of chemical engineers in this country and the difficulties which are experienced in obtaining suitable teaching staff. The Institution has gathered its information from a questionnaire submitted to university professors and the principals and heads of departments of technical colleges.

It is stated that the replies to this questionnaire, when added together, are encouraging. The Institution's assessment is that by 1966, with adequate support, this country could provide 950 chemical engineers a year, compared with just under 300 in 1956. This, the Institution comments, is better than the minimum goal for scientists and engineers as a whole quoted in *Scientific and Engineering Manpower in Great Britain* (1956), though it falls short of the estimates of some leading chemical engineers.

But, the Institution emphasises, the shortage of teachers is a "problem" which is " real and widespread." The increase in the output of trained chemical engineers which has so far been achieved owes much to enterprise and improvisation on the part of professors and other senior chemical engineering teachers. There is, the Institution adds, " the risk of some reduction in quality as a result of the difficulties experienced." The Institution acknowledges that the help which industry has given, directly and indirectly, has borne fruit. It claims, however, that " there is justification for more interest and support, particularly in the provision of student apprenticeship schemes and the seconding of qualified men from industry, to teach for periods of not less than six months."

Space Travel Conference

THE Air League of the British Empire is sponsoring a conference, which its patron Prince Philip will open, at the Royal Festival Hall, London, at 10.30 a.m. on April 14, which will be open to all who are between the ages of sixteen and twenty-three.

Invitations to send parties have been issued to schools, technical colleges, universities and manufacturing companies with apprentice training schemes, but individual applications for tickets will also be accepted. Tickets will be issued strictly in order of application.

There will be four speakers : Professor W. H. McCrea, of the Royal Holloway College, who will discuss the nature and knowledge of outer space and the problems and challenge it represents ; Mr. J. E. Pateman, senior technical executive (guided flight) of Elliott Brothers (London), Ltd., who will describe control systems and navigation ; Mr. A. C. Clarke, former president of the British Interplanetary Society and a well-known lecturer on space travel ; and Mr. D. G. King-Hele, of the Royal Aircraft Establishment.

Marshal of the Royal Air Force Sir Dermot Boyle, Chief of Air Staff, will preside.

The four speakers and Professor Massey, of the Royal Society, will then form a " brains trust " to answer questions on space travel from members of the audience. Chairman of the " brains trust " will be Sir Arnold Hall, director of the Hawker Siddeley Group.

Exhibits will include a model of the United States " Explorer " rocket and of the satellite which it recently launched into orbit.

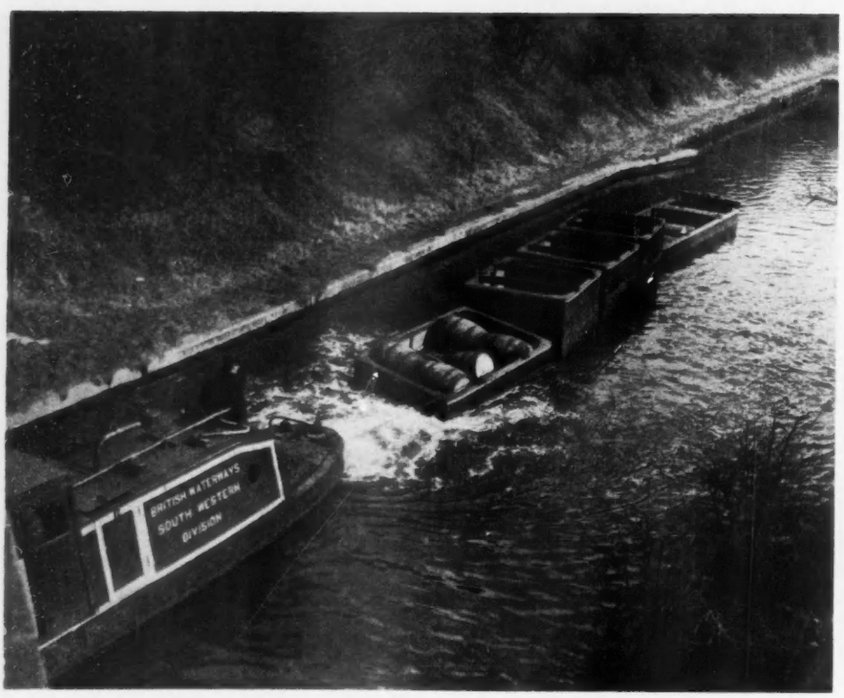
Applications for tickets should be sent to the Air League of the British Empire, Londonderry House, 19, Park Lane, London, W.1.

Evaluation of Materials

THE number and gradations of materials now available to the designer are so great that to consider all possible choices before making a decision is virtually impossible, and accordingly the product may be technically or economically compromised. To help overcome this difficulty, Materials Data, Ltd., 273, Farnborough Road, Farnborough, Hants, has established a Materials Centre where information in standardised form is stored. The basic data for every material are given on two cards, one listing the properties of the material, such as strength, emissivity, permeability and cost, both as supplied and in finished product, and the other giving notes on design criteria and production procedures. The materials covered include metals, alloys, refractories, dielectrics, woods, adhesives, plastics and compositions.

In addition, a system of charts has been prepared to compare, on a basis of equal size, weight, or cost the performance of different materials in different tasks, e.g. to conduct electricity, resist passage, carry load. These charts are plotted on a base of temperature, extending up to 4000 deg. Cent., but provide also for other variations in environment such as humidity.

The facility will be open without restriction to firms or individuals paying an annual subscription. To avoid the need for visiting the Centre for every reference to the information, an inquiry service will also be operated, and a brochure is to be prepared containing photographs of the charts and thereby summarising all the information. We are advised that, while when its information is effectively complete it will need a large staff to maintain it, the Centre already has available a significant amount of data.



A " train " of containers on a Midland waterway. Note the coupling between containers and the lifting eyes on each one for transferring it to a road vehicle

Industrial and Labour Notes

Overseas Trade

The Board of Trade has stated that in February, the United Kingdom's overseas trade was "seasonally lower on both sides of the account." Exports were valued at £265 million (£13,000,000 lower than in January), imports at £288 million (£37,000,000 lower than in January), and re-exports at £12,000,000 (£1,000,000 below January). The visible trade gap was thus reduced to £11,000,000 in February, which was almost the lowest figure since the war.

The Board of Trade says that this narrowing of the gap is mainly a development arising from the favourable trends which have been operating for some time, rather than the result of any sharp underlying change in February itself. Over the four-month period, November–February, the trade gap, averaging £21,000,000 a month, has been smaller than in any period since the war, apart from the autumn of 1950. The Board of Trade's comment on this, in relation to the United Kingdom balance of payments, is that the recent reduction of the monthly trade gap must imply a substantial increase in the level of the current account surplus and very probably also that a surplus is now being earned on visible trade alone. Balance of payments figures for the second half of 1957 are not yet available, but in 1956 and the first half of 1957, when the trade gap was around £50,000,000 a month, there was already only a small payments deficit on visible trade and a surplus at the rate of £250 million a year on the current account as a whole, including "invisibles."

Engineering Exports

When the exports from the United Kingdom in the two months January and February are considered together, their value was about £4,000,000 a month higher than in the comparable period last year. That comparison excludes the silver bullion repayments made last year. This slight overall rise, the Board of Trade says, was made up of a substantial increase in the exports of engineering products which was offset by reductions in nearly all the other export groups.

In January and February, engineering exports averaged £117 million a month, which was £12,000,000 more than a year earlier. The biggest increase was in cars and chassis, exports of which, the Board of Trade says, have risen recently to record levels. In January and February they averaged over £16,000,000 a month, or £6,000,000 more than in the comparable months of 1957. Nearly half this increase was in shipments to the U.S.A. Exports of commercial vehicles and chassis continued to improve and were 24 per cent higher than a year ago, there being large increases in shipments to Australia, New Zealand and South Africa. Exports of aircraft were high in the first two months of this year ; at a value of £8,000,000 a month they were 60 per cent above January–February, 1957. But exports of ships and boats were only half as big as in the first two months of last year. There were substantial increases in machinery exports in January and February. Machinery other than electric, at a value of over £47,000,000 a month, was 6½ per cent higher than at the same time last year, there being particularly heavy shipments to South Africa and New Zealand. Aeroplane engines, which were up by 26 per cent and tractors (up by 22 per cent) accounted for half the rise, and increases were also registered for many other kinds of machinery. Exports of electric machinery and apparatus, at a value of £19,000,000 a month, were 5½ per cent higher than a year earlier.

Exports of metals approached a value of £37,000,000 a month in January and February, a reduction of £3,500,000 compared with a year earlier. Iron and steel shipments were unchanged in value, and manufactures of metals, other than arms and ammunition, were 6 per cent higher this year. The decline was nearly all in non-ferrous metals, partly owing to the fall in copper prices. Shipments of copper and copper alloys and semi-manufactures were 10 per cent less in quantity and 34 per cent less in value than in the first two months of last year. The value of exports of other non-ferrous metals also fell in January and February as a result either of lower prices or smaller quantities.

Copper

The Copper Development Association has recently commented that, at £160 a ton, the price of copper is now lower than at any time since 1947. A record price of £437 a ton was reached early in 1956. The Association goes on to say that "like all commodities the price fluctuations of copper are to a great extent influenced by supply and demand." The violent post-war rise and fall in the price of copper, it adds, has in itself engendered another contributory factor, namely, the confidence of buyers has been shaken. With prices uncertain, the Association observes, users of copper have been unable to plan future production economically.

In an effort to stabilise the price of copper, the Association's statement continues, most producers have individually decided upon a voluntary cut in production. It is confidently predicted, however, that not only the restoration of this cut, but the additional planned production capacity, will ensure for many years to come the stability of price which has not been experienced for a long time. The Association expresses its conviction that "industry will continue to find an ever-increasing need for copper and its alloys, whilst certain manufacturers who may have turned to other materials during the high price period will of necessity and choice return to copper."

Professional Engineers' Appointments Bureau

The Professional Engineers' Appointments Bureau has issued a report summarising its work during 1957. It says that a steady demand for engineers of all grades was maintained during the year, although, during the latter months, some reduction in the number of vacancies notified became apparent. Enrolments of engineers with the Bureau showed no obvious fluctuation and were much the same as in 1956, although they were not so high as in the two preceding years when approximately 2000 enrolments were recorded. The numbers of engineers submitted last year to the notified vacancies were similar to 1956, but lower than in 1955.

The Bureau says that last year placings were not quite as high as in 1956, which was partly due to the decrease in junior placings, a predominant factor in former years. The number of names on the Bureau's register was comparatively constant throughout the year, enabling fair selections to be made for the majority of vacancies notified. In general, notified vacancies covered most branches of engineering, many of them being located overseas. Civil engineering especially, the Bureau reports, has offered some interesting and well-paid posts abroad, whereas mechanical and electrical vacancies tended to be for design, development and research engineers based in the United Kingdom. The more senior vacancies were mainly managerial or administrative. Salary and location requirements insisted upon by individuals continued last year to be the major factors governing selection ; few engineers enrolled with the Bureau without one or other of these restrictive conditions adversely affecting the choice of posts available.

Another matter mentioned in the report is that last year there was a continued increase in the number of those over fifty years of age who enrolled, without there being any comparable increase in vacancies for which employers were prepared to consider this age group. The Bureau says its experience was that there appeared "to be virtually no change in the attitude of employers to consider older men." Any external influence, initiated by organisations interested in this difficult problem, "seemed to make no difference whatever to improving the opportunities for these men."

Queensland Promotion Delegation

The Agent General for Queensland has announced that a Queensland Promotion Delegation is due to arrive in this country on April 8, and will remain here for four weeks. During that time the delegation will be visiting the main industrial centres. The delegation is headed by Queensland's Deputy Premier and Minister for Labour and Industry, Hon. K. J. Morris. The main object is to direct attention to Queensland's industry and its plans for future development, with a view to attracting British industry contemplating overseas expansion. In addition, the delegation will survey the field of permits for manufacture in Queensland under licence. It is stated that members of the delegation are specially anxious to meet as many industrial, banking and building representatives in this country as possible. Any firm or organisation interested is invited to write to the Agent General for Queensland, 409–410, Strand, London, W.C.2.

International Standards

The International Organisation for Standardisation (ISO) is to hold a meeting in this country, at Harrogate, from June 9 to 21: the arrangements are being made by the British Standards Institution. This will be the first occasion that an ISO assembly has visited Britain. As well as plenary sessions, there are to be meetings of fifteen specialised technical committees. Altogether the organisation has eighty-five technical committees concerned with the formulation of international standards: the fifteen which are to meet in Harrogate are those dealing with nuclear energy, cast iron, steel, copper, light metals, mica, solid mineral fuels, machine tools, screw threads, fuel-using equipment, cinematography, photography, pallets, sealed containers and certification marks.

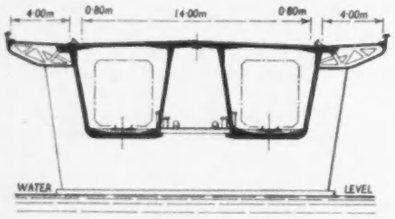
Aerial view of the bridge between Abidjan and Treichville, Ivory Coast

Road and Railway Bridge at Abidjan

Among the most important projects completed in the French overseas territories last year must be reckoned the new road and railway bridge at Abidjan, which replaces a floating bridge which had become inadequate. Its economic importance is very great, as it commands the outlet to the sea of almost the whole of the Ivory Coast as well as part of the Sudan and the Upper Volta.

Principally, the structure, which is illustrated above, comprises a double-deck bridge over the Ebrié Lagoon, 372m long with 89m long access viaducts on either side joined to the existing traffic lines by loops and ancillary fly-overs so as to avoid level crossings.

The central part of the structure comprises eight spans, each 46·5m long. Each span consists of two large, tubular, prestressed concrete girders.



Section through bridge span over the lagoon

The upper flanges constitute a 14m wide carriageway with a 4m wide footpath cantilevered on one side and a similar cycle path on the other. Each of the two lower flanges carries a metre-gauge rail track. The main girders have a free span of 41m each. They are 9·2m wide and 5·8m high, and weigh 800 tonnes. Their bottom flanges are joined by a central structure carrying cables and pipes.

The access sections each consist of a continuous reinforced concrete slab of 1·15m thickness, which is carried over four spans of 21·5m.

An unusual aspect of the bridge is the very deep piled foundations, with piles reaching down to between 38m and 68m below the mean water level. This is necessary because underneath the 10m deep channel there are layers of soft and hard mud, each of which is up to 20m thick, together with lesser amounts of quicksand.

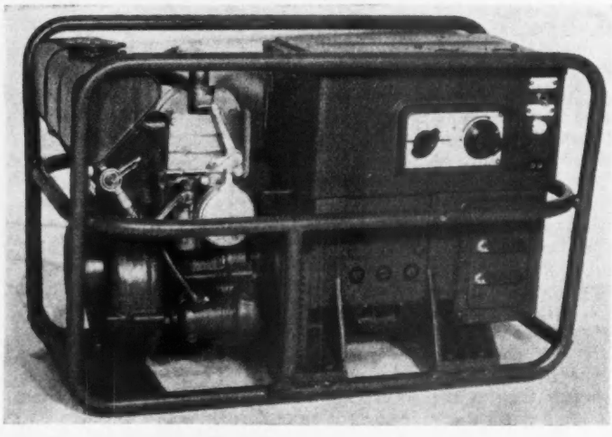
The foundations consist of prefabricated 1·35m i.d. by 1·50m o.d. caissons of prestressed concrete weighing up to 550 tonnes. They were sunk by the Benoto process in either a vertical or a slightly outward-sloping direction. The equipment for drilling the holes and placing the caissons was mounted on pontoons which were linked by a hinged bridge to the nearest pier, which had already been completed. Altogether, 470 caisson sections were placed, each 6m long and weighing 6·5 tonnes. These were subsequently filled with concrete and prestressed.

The tubular main girders were cast in 5·15m long sections and after assembly were floated into position on the piers. They were then raised to the correct level by means of jacks.

All parts of the bridge were prefabricated on the bank and floated into position. In this way a total of 23,000 tonnes was produced and erected within a period of thirty months. The bridge first came into service last May and the access portions were completed towards the end of 1957. At that time, the bridge carried a traffic which, at peak periods, amounted to 2500 vehicles per hour. The design and construction was carried out by Entreprises Boussiron, Paris.

Voltage-Stabilised Generator Set

For use as a universal source of supply for a.c. apparatus as well as for battery charging, A.B. Hägglund and Söner, Ornsköldsvik, Sweden, have developed a generator set of 1200W output with a "transistorised" voltage regulator. Our illustration shows the set, which is designed to fulfil stringent military requirements in electrical as well as mechanical respects, and which comprises an alternator for simultaneous d.c. and a.c. output, and a two-stroke petrol engine.



Voltage stabilised a.c. and d.c. generator set

The alternator may continuously be loaded with 70–50A d.c. at 14–22V or with 1·5kVA, 0·8 p.f. at 230V, 50 cycles per second single-phase. A simultaneous continuous d.c. and a.c. output of up to 1200W can be obtained. The a.c voltage is regulated to within ±5 per cent at load variations between no-load and full load. Insulated according to British Standards, Class E, the set is designed to withstand warm and damp (tropical) and also very cold conditions. Radio interference has been eliminated in accordance with the strictest requirements. Starting is either electrical or manual. Mechanically, the set is dimensioned to withstand shock stresses up to 50 *g*. It is compact and weighs 60 kg.

Electronics Research Centre at Bagneux

The official inauguration took place on March 13 of the Centre Electronique de Bagneux of the Compagnie Française Thomson-Houston. The Centre, which is situated in one of the southern suburbs of Paris, has been under construction since July, 1955, and the first research teams moved in during January, 1957. It is anticipated that it will be completed in the course of April. Covering a substantial site, the Centre comprises several buildings in which the research and development activities of C. F. T. H. will be concentrated. Although the various divisions, which hitherto have been spread out over a number of laboratories in the Paris area, will maintain their independence, they will now have the benefit of a common administrative section and technical services and facilities. The Centre will be concerned with work up to and including the prototype stage, while series production will continue to be the responsibility of Gennevilliers and Asnières factories. The creation of the new Centre, it is stated, does not constitute a reversal of the company's policy of decentralisation; thus, all other recent establishments—in Bohain, Nevers, Angers, Reims and Moulins—are situated in the provinces.

Swiss Industries Fair

This year's Swiss Industries Fair will be held at Basle from April 12 to 22. Three halls, viz. Halls 6, 6a, and the new Hall 7, with the connecting building, will be devoted to machine tools and tools for metal working. Altogether, these halls aggregate a floor area of over 10,000 square metres. New developments which are to be shown for the first time include an electronic single-spindle turret automatic which, it is stated, achieves a saving in operating time of up to 30 per cent, as compared with the usual, mechanically controlled machines. This model is remotely controlled from a control desk.

A copying turning machine with rotating tools and stationary workpiece will be on show, also semi-automatic turret lathes of 102mm centre height, equipped with hydro-pneumatic control. Radial drilling machines with programme control will be exhibited. These machines have preselected speeds and feeds. Small hydraulically controlled horizontal boring heads designed as unit heads, will be introduced, and the latest spark erosion machines will also be on view.

Shippingport Atomic Power Station in Pennsylvania

BY OUR AMERICAN EDITOR

No. II—(*Continued from page* 449, *March* 21)

The first American full-scale atomic power station devoted exclusively to peaceful uses began operation in December, 1957. The station is situated on the Ohio River at Shippingport, Pennsylvania, about 25 miles from Pittsburgh, and was built jointly by the Duquesne Light Company, the Westinghouse Electric Corporation and the U.S. Atomic Energy Commission. The plant employs a pressurised light water reactor and utilises turbo-electric generating equipment of conventional design. The power station is already producing a net output of 60MW and is expected eventually to turn out at least 100MW of electricity.

Core Design

THE active portion of the nuclear core is in the form of a right circular cylinder 6ft in mean diameter and 6ft high. To minimise the amount of enriched U-235 used, the core consists of some highly enriched seed and some natural blanket assemblies. The highly enriched, or seed, assemblies are situated in a square annular region about 6in thick. The area inside and outside the annulus is filled with natural uranium oxide sub-assemblies. A cross-section of the core is shown in Fig. 6. Each seed sub-assembly consists of several plates welded together to form a box. Four of these box units are welded together, with separation being maintained by spacers, to form a central cruciform-shaped hafnium control rod.

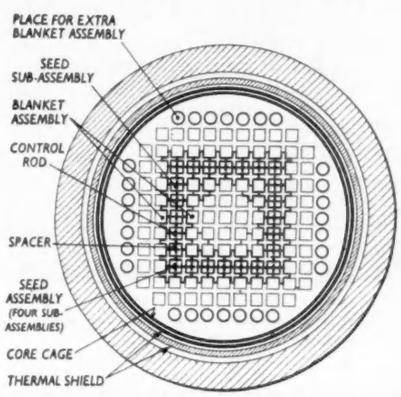


Fig. 6—Cross-section of reactor vessel and nuclear core

The uranium oxide, or blanket, assemblies use a rod as the basic element. These rods are Zircaloy-2 filled with UO_2 pellets and have Zircaloy-2 end plugs welded to each end to form fuel rods. These rods are assembled into bundles of 100 rods each; the assembly is made by mechanically fastening together a stack of seven bundles, each 10in long, obtaining a total length of about 6ft. Provisions are made for removing any individual seed or blanket assembly. The area above the pressure vessel head is flooded with water during the removal operation, and the assembly is transferred to the fuel canal, with this water acting as shielding. Provisions are also available for removing the reactor vessel head and then removing the entire core as a unit, or any assemblies as desired.

A major problem in the operation of a nuclear power plant is the difficulty of determining exactly what is taking place within the reactor vessel with respect to coolant flow, boiling of the coolant, temperature of the fuel elements, or failure of these elements. Suitable instruments for making these determinations have therefore been provided.

The seed assemblies contain a total of 52 kg of enriched U-235, and the blanket contains 12 tons of uranium in the form of UO_2. At the start of reactor life, approximately 60 per cent of the power was produced in the blanket assemblies and 40 per cent in the seed assemblies. The power distribution is a function of reactor life, inasmuch as the reactivity of both the seed and blanket vary with reactor life. The percentage of power produced in the blanket is expected to increase with time. Obviously, power distribution is also a function of the reactor temperature and the position of the reactor control rods.

In the P.W.R. reactor most of the power comes from the fissioning of U-235. However, approximately 8 per cent comes from the fast fission of U-238, and a substantial fraction comes from the fissioning of plutonium. This latter effect increases with the lifetime of the reactor and is expected to reach a substantial fraction after 3000MW days per ton average burn-up in the blanket assemblies. At the start of life, approximately 0·8 atom of plutonium was formed for each atom of U-235 that is fissioned.

The P.W.R. reactor has a negative temperature coefficient of $2 \times 10^{-4}\Delta$ per deg. Fah. This temperature coefficient is of sufficient magnitude to reduce materially the seriousness of the control problem. The reactivity will vary throughout the life of the reactor core, tending to increase during the early part of the reactor life and then decrease. The highly enriched assemblies must be replaced at least once to get maximum life out of the uranium-oxide blanket assemblies. Obviously, sufficient control rod area must be provided to permit the reactor to be sub-critical with a reasonable margin in its most reactive condition. Inasmuch as each additional control rod imposes a severe penalty in the mechanical design, it has been necessary to keep the number of rods to an absolute minimum. To increase the loading of the highly enriched assemblies and thus give them increased life, burnable poisons have been added to these fuel plates. This poison is removed by the capture of neutrons during the life of the reactor. Sufficient control must be provided to compensate for the equilibrium xenon poisoning. The control-drive mechanism functional requirements include the following:—

(*a*) Number of rods—twenty-four, with provisions for four more.
(*b*) Rod speeds—20in per minute.
(*c*) Minimum scram rate—200in per minute.
(*d*) Permissible delay after scram signal—0·1 second.
(*e*) Fail safe on loss of power.
(*f*) Accuracy of position indicator—1·5in.

The basic criteria for the thermal design of the P.W.R. are as follows:—

(*a*) Nucleate boiling must not occur at the hot spots during steady-state operation.
(*b*) Bulk boiling must not occur in water leaving the hot channel during loss of coolant flow transient.
(*c*) Fuel element internal and surface temperature must be compatible with the properties of the selected fuel element material.

To prevent nucleate boiling, the maximum coolant temperatures must be below 636 deg. Fah., which is the saturation temperature for the 2000 lb per square inch operating pressure. To calculate the maximum metal surface temperature for a given assumed set of parameters, the core hot-channel factors must be known. These factors represent such items as the peak-to-average flux ratio and the maximum permissible deviation from the average with respect to coolant channel width, fuel element thickness, eccentricity of fuel within an element and variation in fuel loading within the element itself.

In the seed assemblies, the peak power density is 277W per cubic centimetre with an average power density of 81W per cubic centimetre. In the blanket the peak power density is 120W per cubic centimetre and the average power density is 32W per cubic centimetre. In the seed assemblies the maximum heat flux is 382,000 B.Th.U. per hour per square foot, and the average heat flux is 112,000 B.Th.U. per hour per square foot. In the blanket the maximum heat flux is 240,000 B.Th.U. per hour per square foot, and the average is 65,000 B.Th.U. per hour per square foot. Thirty-three per cent of the flow through the fuel elements of the nuclear core goes through the seed assemblies, which, however, represent only about twenty per cent of the area. The water velocity in the seed assemblies is 20ft per second, and that in the blanket assemblies is only 9·8ft per second.

Reactor Materials

The highly enriched fuel assemblies of the reactor consist of zirconium-uranium alloy plates clad with Zircaloy-2. The zirconium-uranium alloy fuel sections of these plates are relatively corrosion-resistant and are also metallurgically compatible with the Zircaloy-2 cladding. This increases the probability of a good bond between

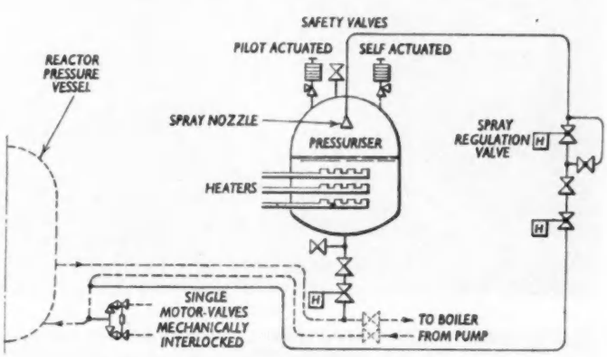


Fig. 7—Diagram of P.W.R. pressurising system

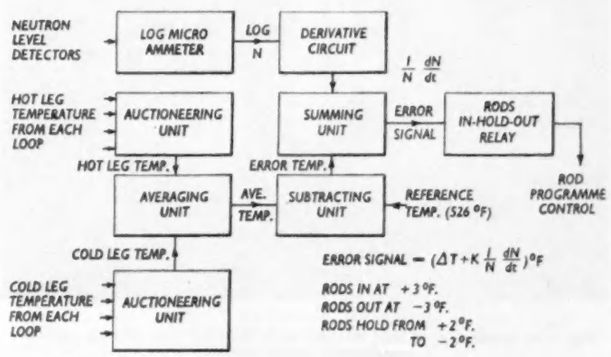


Fig. 8—Diagram of reactor power and temperature control system

PRESSURISED WATER REACTOR POWER STATION AT SHIPPINGPORT

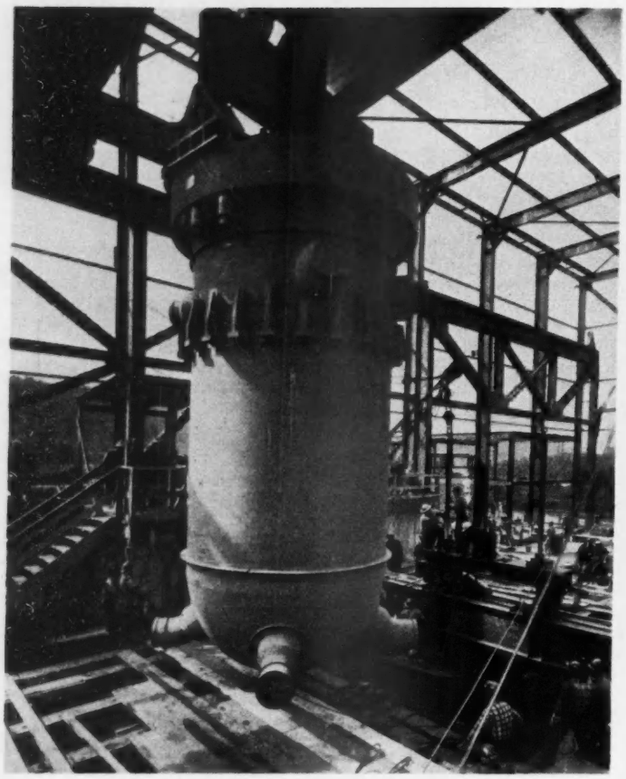


Fig. 9—Installation of reactor pressure vessel at the Shippingport power station

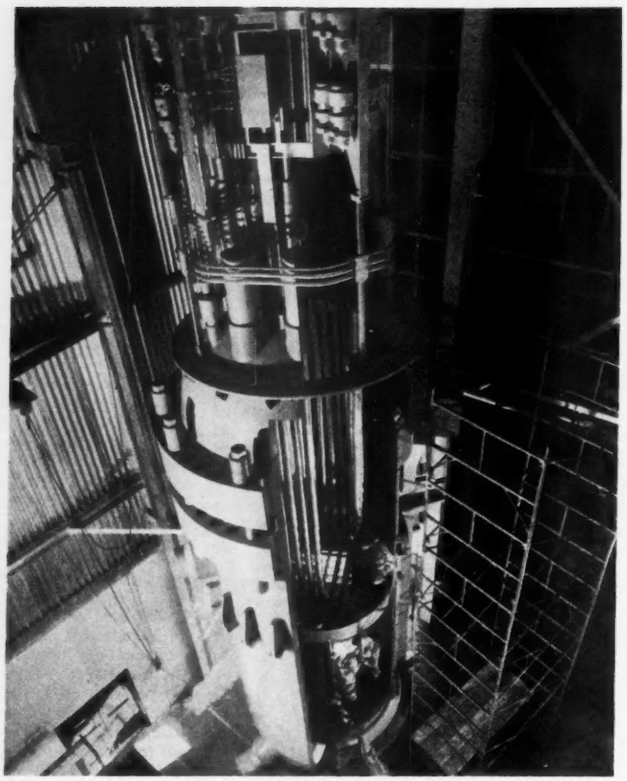


Fig. 10—45ft high full-scale mock-up of the pressurised water reactor, showing nuclear core and control rod mechanism

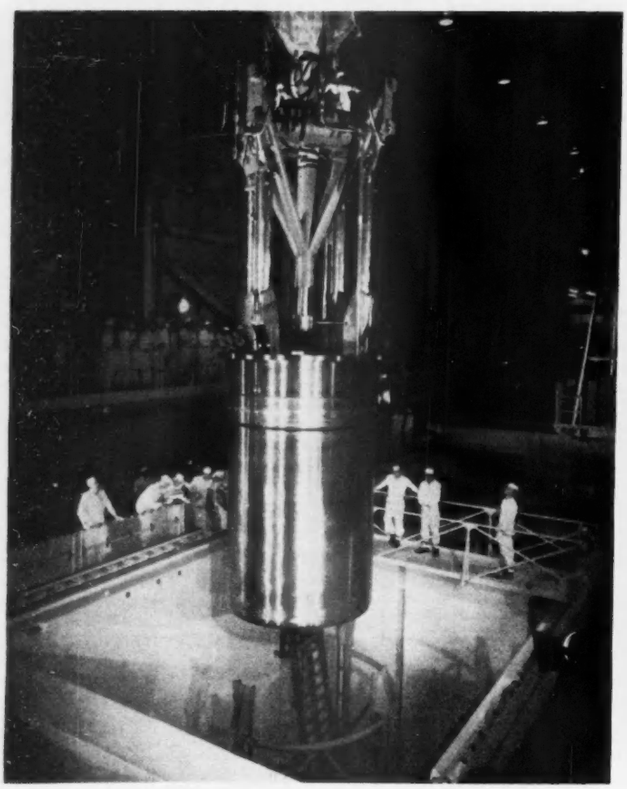


Fig. 11—Installation of first nuclear core, weighing over 50 tons, at the Shippingport power station

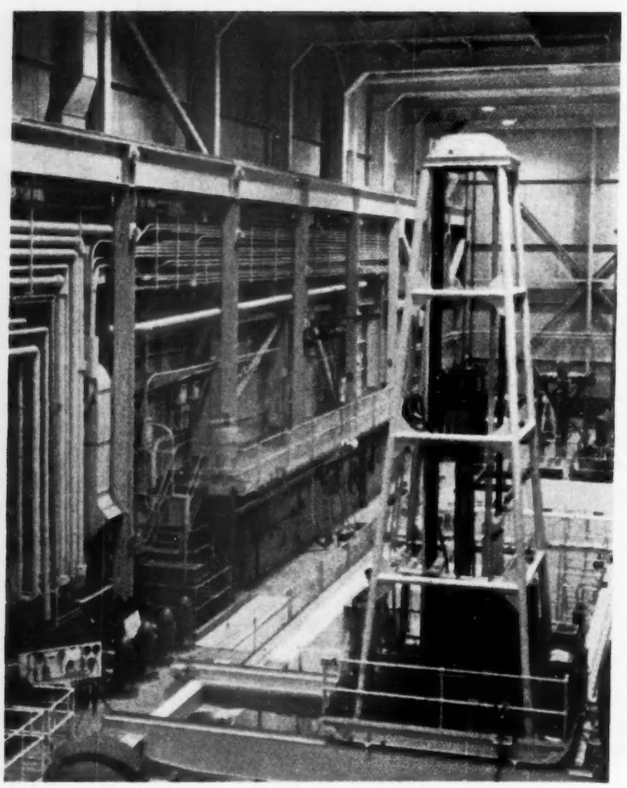


Fig. 12—Interior of fuel handling building, with 100-ton crane and fuel handling canal

the centre section and the clad faces. No imperfections in the clad surfaces are expected. However, if there should be, this would cause only minor corrosion of the centre section, would not cause any mechanical deformation of the plates and would release only negligible quantities of fissionable material into the coolant stream. The plate design was chosen to give high heat transfer area, required because of the high power density in the seed assemblies.

For the blanket assemblies, a material that permits the highest possible multiplication constant is desirable. This is because the ratio of power produced in the blanket to power produced in the seed varies approximately as k/(1-k). Pure natural uranium would, therefore, from a nuclear sense be the most desirable material. Such natural uranium is, however, extremely unsatisfactory both from a corrosion and a radiation damage viewpoint. There are two possible solutions. The uranium can be clad sufficiently well that the coolant water never reaches the uranium surface, and with sufficient strength to prevent any dimensional changes due to radiation damage. However, it is highly unlikely that cladding can be sufficiently perfect never to expose the uranium to the coolant water. The other possible solution is to add something to the uranium to improve its characteristics, which can be done by making a uranium alloy, such as uranium-molybdenum, uranium-silicon, or uranium-niobium, or by utilising the uranium in the form of uranium-oxide.

All alloying elements that improve the radiation-damage resistance or the corrosion resistance properties of uranium alloys tend to give poor neutron economy, since the alloying elements have relatively high cross-sections for the capture of neutrons. Even if neutron economy is ignored, none of the alloys is suitable from both a corrosion resistant and radiation-damage viewpoint. This means that the life is seriously limited either by radiation damage or by corrosion, or both. The radiation may cause a rupture of the cladding and subsequent failure of one element due to corrosion, or the corrosion may be initiated by a cladding defect. In either event, after several days of exposure to the hot water all of the uranium alloy and the contained fission products in the affected fuel element might be released to the coolant stream. Uranium alloys are also, in general, more expensive than the uranium-oxide fuel elements and also give less power production in the blanket assemblies than uranium oxide.

Uranium oxide is an excellent material for the blanket fuel elements, because it is completely inert in high-temperature water and is also satisfactory from a radiation-damage viewpoint. The uranium oxide can be readily cold compacted into pellet form and then sintered to increase the density to a value in excess of 90 per cent of theoretical density. By mass-production techniques the dimensions can be ground to extreme accuracy and the uranium oxide loaded into Zircaloy tubing. The centre temperatures of the uranium-oxide fuel elements may be as high as 2200 deg. Fah., but this appears to cause no difficulty because it is still approximately 3000 deg. Fah. below the melting temperature of uranium oxide. The Zircaloy-2 tubing is ideal from a performance viewpoint. Its inherently high cost is a disadvantage ; however, this disadvantage is more than compensated for by its decreased cross-section for the capture of neutrons. The control rods of the reactor are made of crystal-bar hafnium and are homogeneous rods. The hafnium has ideal mechanical properties and is also extremely corrosion-resistant.

For application to components such as mechanisms, valves and pumps, it is necessary to have materials that not only will withstand the corrosive effects of the high-temperature water but also have good wear characteristics when in rubbing contact with other than the high-temperature water itself. Since most of the materials that have the best corrosion-resistance have inherently poor wear-resistance and vice versa, a thorough investigation was required to determine the combination of metals that presented the best compromise for the various applications. First, a large number of tests were made for short periods by means of simple shapes ; later, full-size components were made and tested under actual service wearing conditions in the high-temperature water. The basic materials for the static parts of the reactor plant, such as heat-exchanger vessels, exchanger tubes and pipes, is A.I.S.I. Type 304, an 18-8 stainless steel with very low carbon content. Stressed parts, such as springs, are made of Inconel or Inconel-X. Rubbing parts, such as those in the control-drive mechanisms, are made of hardened stainless steel, chromium-plated stainless steel and various grades of Stellite. Magnetic parts, such as magnetic slugs for control-rod position indicators, are of martensitic stainless steels.

Auxiliary Systems

A number of auxiliary systems are connected into the primary coolant circuit to ensure proper operation of the plant. Some of these, such as the pressurising system and the purification system, are in use continuously, while others are required for intermittent operation. In addition, there are the usual power station auxiliary systems, such as cooling water, compressed air, and electrical supplies.

The coolant charging system is used for filling the primary plant prior to operation and for maintaining the proper fluid level in the pressuriser. One 100 gallons per minute low-head pump is used for filling and two 25 gallons per minute high-pressure pumps are required for the intermittent make-up function. The charging system also contains facilities for charging fresh resin into the purification demineraliser and back-flushing the primary loops. No purification equipment is provided in this system, as the water from the boiler make-up water equipment meets primary water specifications.

Changes in the average core temperature due to power excursions and changes in reactivity and subsequent correction by control-rod movement make the system coolant volume a variable. These volume changes would cause wide variations in the coolant-system pressure if the plant were operated as a solid system. The function of the pressuriser is to regulate the system pressure within a lower limit set by the reactor hot-spot temperature and an upper limit determined by the safety and relief-valve settings. The relief pressurising system, which is shown in Fig. 7, maintains a 2000 lb per square inch saturation steam head in a separately heated pressurising vessel. This vessel has a volume of approximately 300 cubic feet and contains about 100 cubic feet of water. The size is a function of the total volume of coolant and the transport time of the water in the loops, as well as the rate of change of power. The heat to the pressurising vessel is supplied by electric immersion heaters, which are sufficient to raise the temperature of the water in the pressurised tank consistent with a 200 deg. Fah. per hour heating rate for the entire plant.

A fraction of the coolant that passes through the nuclear core must be purified to limit the activity build-up of the long-lived impurities in the water. This is done by passing a certain quantity of the coolant through a by-pass demineraliser, which removes soluble and insoluble matter. The reactor coolant-purification system consists of two parallel loops, each of which provides purification for two of the four reactor coolant loops.

The activity in the ion-exchange resin from the purification system and in the decontamination fluids and primary system effluent is too high to permit dumping in the river. The volumes involved make packaging and subsequent disposal at sea not feasible. The waste disposal system consists of two-stage evaporation, to reduce bulk, and subsequent underground storage of high-activity evaporator bottoms at the site. Spent resin from the demineralisers is transferred by flushing, in the form of a slurry, directly to underground storage. Provision for the collection and storage of radioactive gases has been made. The evaporator feed is from 9000 to 21,000 cubic feet per month depending primarily on the decontamination procedure. The evaporator vapour is condensed and then diluted with condenser cooling water before release to the river. The permissible activity released to the river is being taken at 10 per cent of the standard tolerance.

Reactor Control

The reactor plant is controlled to maintain a constant average temperature of the primary coolant, as shown in Fig. 8. Therefore, the control method used is one of average-temperature error detection and correction. On-off control of rods is initiated at plus or minus 3 deg. Fah error, with a plus or minus 2 deg. Fah. deadband. Because of the slow response of the temperature-sensing elements and of heat transfer around the loops, the corrective action of the control would produce overshoot and oscillation of the system even if a considerably wider range of temperature variations were permitted. For this reason a damping effect is provided by incorporating the rate of nuclear level change into the control signal. The normal mode of operation in the power range and during low-power standby is by automatic control of the rods, as described. If desired, manual control can be employed by the operator. As designed, the external temperature-control loop permits the negative temperature coefficient of reactivity to adjust power without motion of the rods for load changes of the order of 10 to 20 per cent of full-power rating. For larger load changes, the external loop assists the temperature coefficient by introducing rod motion to make a more rapid adjustment of the reactor power. Temperature measurements for the control system are made by resistance thermometers in the loops. The temperatures are measured at the boiler and reactor exits and are averaged.

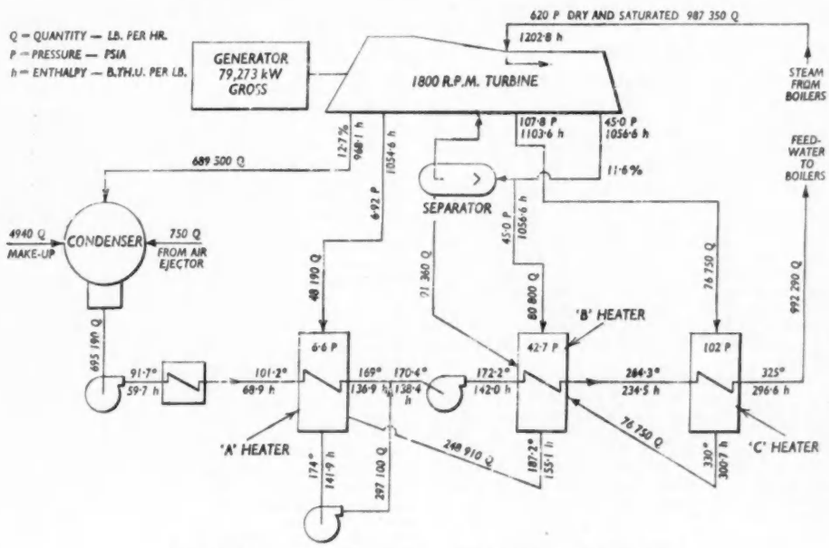


Fig. 13—Diagram of steam cycle and heat balance of plant

(To be continued)

Personal and Business

Appointments

MR. T. HERD has been appointed general manager of the London sales office of Brook Motors, Ltd.

MR. FREDERICK BAILLIE has been appointed works manager of the Scottish plant of I.B.M. United Kingdom, Ltd.

MR. J. R. ALLAN has been appointed joint managing director of Acme Ventilating, Ltd., and Mr. P. Lowe, sales director.

MR. E. T. R. BALL, A.M.I.E.E., has been appointed managing director of the British Electric Transformer Company, Ltd.

MR. C. C. TAYLOR has been appointed a director of Francis Morton and Co., Ltd., constructional engineers, Liverpool.

MR. KENNETH IVOR EADES has been appointed sales manager of R. Blackett Charlton and Co., Ltd., and Charlton Weddle and Co., Ltd.

MR. J. D. HANDYSIDE has been appointed controller of research of the National Institute of Industrial Psychology with effect from April 1.

ROSITE, Ltd., Cheney Manor, Swindon, has announced the appointment of Mr. B. W. Hymass as manager and Mr. J. G. Selby as sales manager.

MR. DENIS S. PLAYER has been elected deputy to Mr. Sydney Player, chairman of the Newall Engineering Company, Ltd., Peterborough, and its subsidiaries.

MR. R. A. LE PAGE has been appointed a director of Mancuna Engineering, Ltd. Mr. N. S. Stedman has assumed responsibility for the southern area office in Surbiton.

THE BRITISH BROADCASTING CORPORATION announces that Mr. Graham Phillips, A.M.I.E.E., has been seconded to the Kenya Government Broadcasting Service as chief broadcasting engineer.

THE TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY, Ltd., has announced that Mr. H. F. Wilson, Comp. I.E.E., and Mr. C. L. G. Fairfield, M.I.E.E., A.M.I.Mech.E., have been appointed directors.

GOODENOUGH PUMPS, Ltd., has announced the following staff appointments to the Goodenough Engineering Group : Mr. H. W. Stannard, general manager ; Mr. B. J. Sharman, commercial manager ; Mr. N. C. Way, service manager, and Mr. L. Rue, Midlands manager.

THE MINISTRY OF HOUSING AND LOCAL GOVERNMENT announces that Mr. S. L. G. Beaufoy, F.R.I.B.A. has been appointed chief housing and planning inspector, in succession to Mr. F. Collin Brown, F.R.I.B.A., who is retiring on May 5. Mr. E. G. S. Elliot will succeed Mr. Beaufoy as chief technical planner, and Mr. J. R. James becomes a deputy chief technical planner.

SMALL AND PARKES, Ltd., has announced the following appointments : Mr. F. P. Parkes, works manager (friction materials) ; Mr. W. L. Varty, works manager (textiles) ; Mr. Edward J. Parsons, sales manager, friction materials division, Manchester, and Mr. W. A. Parkes, manager of the London sales area. Mr. Harold Hicklin, works manager, is to retire on April 1, after more than fifty years' service with the company.

MESSRS. RENDEL, PALMER AND TRITTON have announced that Mr. H. Scrutton, M.I.C.E., Mr. H. F. Merrington, M.I.C.E., and Mr. B. G. R. Holloway, M.I.C.E., will be taken into partnership early in April. Mr. A. J. Clark, Mr. F. A. Greaves and Mr. E. Bateson are retiring shortly from the partnership, but will then join their group of consultants. Mr. P. R. Robinson, M.I.C.E., became a consultant to the firm last July.

Business Announcements

PATERSON ENGINEERING COMPANY, Ltd., states that its new address is 129, Kingsway, London, W.C.2 (telephone, Holborn 8787).

MAJOR-GENERAL G. N. RUSSELL has been elected president of the Institute of Transport for the year 1958–59, commencing on October 1.

MR. G. H. BLACK, director of the Kestner Evaporator and Engineering Company, Ltd., has left London by air for a short visit to the United States.

ASSOCIATED LEAD MANUFACTURERS, Ltd., has moved to Clements House, 14–18, Gresham Street, London, E.C.2 (telephone, Monarch 4400).

DR. P. H. SYKES, a director of the British Oxygen Company, Ltd., has been elected chairman of the Low Temperature Group of the Physical Society.

MR. N. R. D. GURNEY, M.I.E.E., has been appointed sales manager, plant department, of Metropolitan-Vickers Electrical Company, Ltd.

BRITISH GECO ENGINEERING COMPANY, Ltd., announces that its induction heating department has moved to new premises at Station Road, Edenbridge, Kent.

NORTHERN ALUMINIUM COMPANY, Ltd., states that its Birmingham area sales office has been moved to new premises at Devonshire House, Great Charles Street, Birmingham, 3 (telephone, Central 7393).

MR. J. N. TOOTHILL, general manager of the Scottish group of Ferranti, Ltd., has left by air for India. During his three weeks' visit he will meet government officials and Indian Air Force officers.

TALBOT TOOL COMPANY, Ltd., states that it has acquired the share capital and premises of K.D.L. Precision Engineers, Ltd., Crowhurst Road, Hollingbury, Brighton, 6, Sussex. Two directors, Mr. R. W. Griffiths and Mr. G. A. Bennett, have been appointed from the parent company to be directors of the K.D.L. Company.

THE BRITISH PLASTICS FEDERATION announces that the fabricators group management committee has formed a section within the group to cater for the interests of processers of P.T.F.E. The proposed name of the section is the fluorocarbons section and the proposed terms of eligibility for membership are : members of the Federation engaged in the processing for sale of fluorocarbon polymers, e.g. polytetrafluoroethylene and polytrifluorochloroethylene.

K. S. PAUL, Ltd., Great Western Trading Estate, Park Royal Road, London, N.W.10, announces that it has taken over the agencies of the following West German machine tool manufacturers : Wanderer-Werke A.G., Haar, near Munich (milling machines and thread milling machines) ; Herminghausen-Werke G.m.b.H., Eichelkampstrasse 4–10, Hannover-Wülfel (small diameter precision centreless grinders with automatic cycling) ; Otnima Maschinenfabrik, Oberndorf/N. (special purpose machine tools for milling, drilling, tapping, &c.) ; A. Burger and Söhne O.H.G., Jahnstrasse 33, Sindelfingen-Stuttgart (small hydraulic presses) ; and Keller and Knappich G.m.b.H., Ulmer Strasse 68–74, Augsburg (automatic transfer welding machines).

Contracts

FOLLAND AIRCRAFT, Ltd., are to manufacture a development quantity of fourteen " Gnat " transonic two-seater trainers for the R.A.F. The aircraft will be powered with the Bristol " Orpheus " " B.Or.4 " of 4230 lb thrust, an engine with an improved overhaul life and fuel consumption compared to the 4850 lb " B.Or.3." The wing and tail surfaces are larger than in the light fighter, and there are both ailerons (outboard) and flaps.

AMPOL PETROLEUM, Ltd., of Sydney, Australia, has placed an order with Broken Hill Pty., Ltd., for a 32,000-ton deadweight oil tanker to be built at the Whyalla yard, South Australia. The ship will have a length overall of 668ft by 87ft moulded breadth, a loaded speed of 15½ knots. A single set of two casing double reduction geared turbines, taking superheated steam from two oil-fired, water-tube boilers, and developing 12,500 service s.h.p. will propel the ship.

Miscellanea

COLD SETTING ADHESIVES.—A note from Belsize Metal Products, Ltd., Spragg Street, Congleton, Cheshire, states that new adhesives added to the " Agomet " range have wider applications. They are suitable for bonding all types of metals, hard synthetic resins and plastics, ceramics and glass.

THE PENINSULAR AND ORIENTAL STEAM NAVIGATION COMPANY.—The 45,000-ton turbo-electric passenger liner, at present under construction at the Belfast yard of Harland and Wolff, Ltd., has been given the name of " Canberra." The British Thomson-Houston Company, Ltd., is constructing the propelling machinery, consisting of two 32,200kVA, single-cylinder turbo-alternators, taking steam at 700 lb per square inch gauge and 950 deg. Fah., and two double-unit 42,500 s.h.p. propulsion motors.

TRACTOR FRONT-END LOADER.—A front-end loader capable of lifting a weight of over 10 cwt to a height of 9ft 2in in about six seconds has been developed by David Brown Construction Company, Ltd., Hanworth Park, Feltham, Middlesex, for use with the " DB 900," 40 h.p. industrial tractor. A ¾ cubic yard dirt bucket is supplied as a standard with the loader: alternative attachments available include a ½ yard bucket, fork lift attachment, lifting boom and a bulldozer blade.

IRON AND STEEL INSTITUTE.—The eighty-ninth annual general meeting of the Iron and Steel Institute is to be held in London on Wednesday and Thursday, May 7 and 8. The proceedings will begin, at 4, Grosvenor Gardens, S.W.1, on May 7 at 2.45 p.m., when, following formal business, Mr. C. R. Wheeler is to be inducted as president and will deliver his address. In the evening, at 7 for 7.30 p.m., the Institute's dinner will take place at Grosvenor House, Park Lane, W.1, when Mr. Reginald Maudling, the Paymaster-General, will be the principal guest. There will be sessions for the presentation and discussion of papers at 10 a.m. and 2.30 p.m. on Thursday, May 8, at 4, Grosvenor Gardens, S.W.1.

EXHIBITION OF NICKEL DEVELOPMENTS.—An exhibition, designed to show the latest uses and developments of nickel, nickel alloys and related materials, is to be held by The Mond Nickel Company, Ltd., at the Grand Central Hotel, Belfast, from April 14 to 18. Displays are being planned to show corrosion resistance, surface protection, high magnetic permeability, weldability, controlled expansion and mechanical properties at temperatures between 900 deg. Cent. and sub-zero. One particularly dramatic demonstration will show how an alloy of platinum and rhodium can be used as a catalyst to re-ignite jet engines after a plane-out, and another exhibit will be a red-hot nickel alloy rod carrying a load equivalent to 7 tons per square inch. Part of the exhibition will be devoted to displays and tests of spheroidal graphite cast iron.

OIL DRILLING IN THE BAHAMAS.—An announcement from the Bahamas California Oil Company and Bahamas Gulf Oil Company says that it is proposed to drill an exploratory test well on Cay Sal Bank, a small island approximately 180 miles south-west of Nassau. The actual drilling operations are scheduled to start in April. The well will be drilled under oil prospecting licences held by the two firms, which are wholly owned subsidiaries of Standard Oil Company of California and the Gulf Oil Corporation respectively. The site was selected after two years of extensive seismic work over Cay Sal Bank ; the well will cost nearly 3,000,000 dollars. It will be drilled to a maximum depth of 15,000ft from a self-contained platform located in 30ft of water. The platform will be above anticipated wave crests and will contain all the necessary drilling equipment, including derricks, engines and mud pumps, together with accommodation for the drilling crew.

STATISTICAL SAMPLING IN INDUSTRY.—A one-day conference on statistical sampling in industry, organised by the Birmingham group of the Industrial Applications Section of the Royal Statistical Society, will be held at the Birmingham College of Technology on Wednesday, May 7. There is a great deal of evidence that the collection and analysis of numerical information is a basic need of industrial management, and the collection of this information can be done effectively and economically by using suitable sampling methods. The speakers at the conference will therefore outline techniques designed for the purpose and indicate appropriate methods of analysis. The conference is designed to appeal particularly to people responsible for production, inspection and accounting, as well as to statisticians. The conference fee is 30s., including luncheon ; further details and application forms can be obtained from Mr. D. Goldberg, A.E.I. Lamp and Lighting Company, Ltd., Melton Road, Leicester.

ISOTOPE COURSES AT HARWELL.—A course on radioisotopes designed to give senior executives in industry an appreciation of the possible applications of these materials will be held at the Harwell Isotope School from September 23 to 26. Two similar courses have been arranged from April 15 to 18 and July 8 to 11 for members of the Institute of Directors only. Each course consists of lectures on the elementary principles of work with radioactive isotopes, with the emphasis strongly towards their application as tools in industry and research. The lectures will be given in as non-technical a manner as possible by scientists experienced in the field ; they will be supplemented by visits to a reactor and to the laboratories of the isotope division at Harwell and at the Wantage Radiation Laboratory, near Harwell. The lectures and demonstrations will be given in the Cockcroft Hall at Harwell. Over the period of the course delegates will stay in an Oxford college ; transport from Harwell to Oxford and back each day will be arranged. The fee for the course, including accommodation, meals, transport and lectures is £40, payable in advance. Applications for places will be accepted strictly in rotation. Application forms are obtainable from the Registrar, Isotope School, Atomic Energy Research Establishment, Harwell.

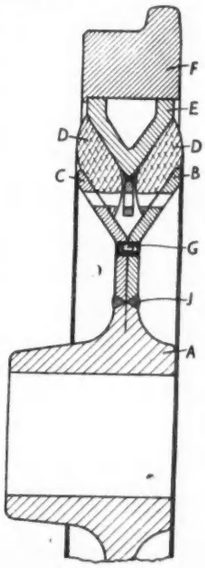
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

RAILWAY ENGINEERING

791,371. May 11, 1956.—Disc Wheels, Klockner-Georgsmarienwerke Aktiengesellschaft, Osnabruck, Germany.

The invention relates to disc wheels, more particularly for use in railway rolling stock, and provided with resilient insertions stressed principally for compression, the insertions being interposed between two acute-angled surfaces of a wheel rim connected with the tyre of the wheel, and the inner surfaces of a V-section annular flange connected with the wheel hub. As will be seen from the drawing, the disc wheel of the invention comprises a wheel hub *A*. The disc proper comprises two angled sheet metal apertured discs *B* and *C*, combined to form an annular flange of V-section, rubber-like insertions *D* and, finally, a V-section wheel rim *E* with shrunk-on tyre *F*. The hub is preferably a drop forging. The two sheet metal discs in the drawing are identical and are joined together back to back by dowels *G* fixed in position by welds after the insertions have been slightly precompressed. The hub and the annular flange are joined by seam welding along *J*, the welded joint also holding the two discs together. The insertions *D* are preferred to be ring-shaped bodies of a rubber-like mouldable synthetic plastic material and preferably a plastic, as that known under the registered trade mark "Vulkollan." In view of the comparatively low precompression to which the insertions need be subjected if they consist of the specified plastic, they form resilient cushions capable of storing an unusual amount of elastic deformational energy both in the radial as well as in the axial direction. Unlike rubber, these insertions need not be subjected to high axial precompression, as in the case with rubber to enable it reliably to absorb the loads that occur in operational service, although the rubber is thereby deprived of the major proportion of its elastic potential. Practical tests have proved that precompression between 6·8 to 8 tons is sufficient for the wheels, according to the invention, whereas rubber-cushioned wheels with a T-section ring and disc-shaped rubber insertions require, for instance, a precompression of from 24 to 60 tons.—*February* 26, 1958.

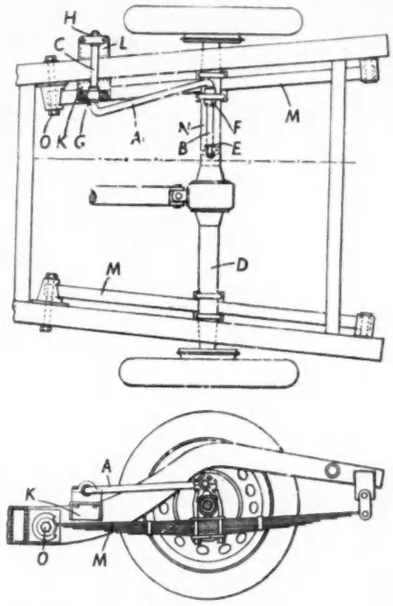


No. 791,371

ROAD TRANSPORT

791,523. April 15, 1955.—Motor Vehicle Suspension, Rolls-Royce, Ltd., Nightingale Road, Derby. (*Inventor: Geoffrey Bastow.*)

The invention relates to the suspension of motor vehicles and applies particularly to a vehicle of which the rear axle is solid. It has for one of its objects an anti-roll rod for use in conjunction with a solid rear axle which can be located entirely on one side of the propeller shaft. Another object is to control the "shake" which is produced by rocking of the axle in side elevation on the springs. As the drawing shows, a rod of steel *A*, having a high torsional resistance and being in the shape of a letter "Z," is mounted in four rubber bushes, two at each end of its parallel arms *B* and *C*. The rear portion of the rod is above and parallel to the rear axle tube *D*, on which it is mounted by rubber bushes *E* and *F*. The front portion is mounted by rubber bushes *G* and *H* on the frame side member by brackets *K* and *L* welded to the frame. The rubber of these bushes is in compression and permits partial rotary movement of the rod arms by distortion—but not sliding. The more heavily loaded of these bushes are larger than the others and the rubber is held compressed by steel sleeves. The road springs *M* are secured to the axle tubes *N* by the usual U-bolts and saddle pieces. One of the U-bolts is longer than the others and is utilised to secure the bush *F*. The length of the Z-bar and the axes of oscillation of the arms *A* are carefully selected relative to the axis of the rear axle and that of the spring eye *O*, so that under spring deflection the axle can only move along a path dictated by the geometry of the centre part of rod *A* and the front half of spring *M*, and cannot move substantially in a rotary sense. Any tendency of the car frame and body to roll is resisted by the torsional stiffness of the middle portion of rod *A*, and this is achieved by a rod entirely on one side of the propeller shaft. It is only necessary to fit a rod on one side of the chassis though rods could be fitted on both sides if desired.—*March* 5, 1958.

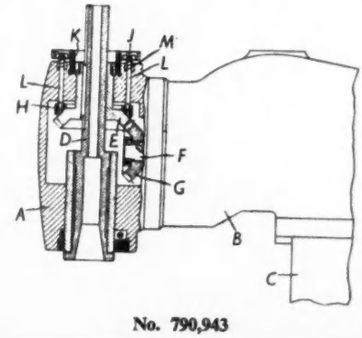


No. 791,523

MACHINE TOOLS

790,943. October 4, 1955.—Damping Vibrations in a Machine Tool Spindle, Hans Deckel, Irmgardstrasse 20, Munich-Solln, Germany, and Friedrich Wilhelm Deckel, of Haus, Lorettohöhe Zug, Switzerland.

The invention provides an arrangement for damping vibrations in a machine tool spindle characterised in that a gear wheel rigidly connected with and driving the spindle simultaneously acts as one element of a friction brake with which element co-acts a non-rotatable brake ring coaxially surrounding said spindle and movable in the direction of its axis. As shown in the drawing, the drilling or milling head *A* on the headstock *B* of a machine tool *C* carries a hollow spindle *D* connected with and driven by a bevel wheel *E* from a drive shaft *F* in the headstock through a bevel wheel *G*. In certain unfavourable working conditions, e.g. when the tool is applied laterally to a workpiece, the spindle *D* with the tool may be caused to vibrate. In order to prevent this, the head *A* is provided with a damping arrangement consisting of a manually adjustable friction brake. The bevel wheel *E* forms one element of this friction brake, against which a non-rotatable brake ring *H* is capable of being pressed. The application or release of the brake ring is effected by a setting ring *J* having the form of a gland nut which can be manually screwed down. The connection between the setting ring *J* and the brake ring *H* is formed by a number of studs *L* screwed into the brake ring *H* and loaded by springs *M*. A scale on the setting ring works opposite a fixed reference mark on the collar and indicates the setting of the friction brake.—*February* 19, 1958.

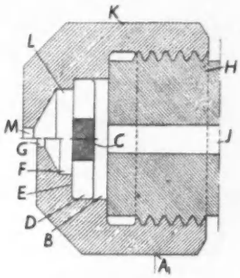


No. 790,943

BURNERS AND SPRAYERS

791,399. May 20, 1954.—Sprayers for Liquid Fuel, Louis Edouard Sallot, 9, rue du Général Leclerc, Bois-Colombes (Seine), France.

The invention relates to a liquid fuel sprayer which is designed for a fixed output range. Referring to the drawing it will be seen that the body *A* comprises a cylindrical recess *B*, in which is inserted a baffle *C* provided with inclined slits *D*. The baffle is held in position against a seating *E* by the pressure of the fuel. The seating should be finished to obtain a completely tight joint between its surface and that of the baffle it contacts. The chamber in which turbulence is effected is constituted by a cylindro-conical chamber *F* in which the fuel is caused to rotate before being expelled through orifice *G*. The body *A* is screwed to the extremity of a tube *H* having a bore *J* for feeding liquid fuel under pressure. The sprayer thus described corresponds to a certain output. Should a sprayer of higher output be required, the body *K* is chosen, of which only the cylindro-conical chamber *L* and orifice *M* differ from those of the body *A*, being dimensioned to give the required higher output. The sprayer can be used for fuel comprising an emulsion of liquid and air, or liquid and steam.—*March* 5, 1958.

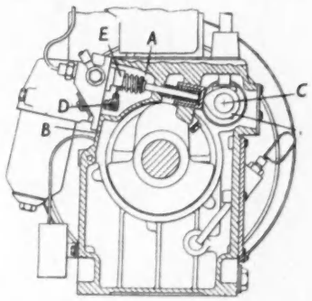


No. 791,399

INTERNAL COMBUSTION ENGINES

791,482. September 23, 1955.—Compression-Ignition Engines, Petters, Ltd., Causeway Works, Staines, Middlesex. (*Inventor: Douglas Alexander Law.*)

The invention relates to compression-ignition engines and more specifically to fuel injection pumps. It consists in a compression-ignition engine having a fuel injection pump and associated fuel control rod mechanism, both mounted wholly or mainly within a recess in the wall of the crankcase on the opposite side of the crankshaft to the camshaft, so that leakage of fuel from the pump cannot enter the crankcase and the control rod mechanism is not exposed to dust and dirt. As shown in the drawing, a recess *A* is formed in the wall of the crankcase *B* of an engine, on the opposite side of the crankshaft to the axis of the camshaft *C*. Within this cavity is a fuel pump control rod *D* and part of a fuel pump *E*, the pump body closing the cavity. The pump plunger, a push rod and tappet are all mounted within the crankcase between the camshaft and the fuel pump. The fuel pump is controlled by a conventional rack and pinion arrangement, although, if desired, a control rod may be connected to the fuel pump mechanism by a lever.—*March* 5, 1958.



No. 791,482

Launches and Trial Trips

BEN BARVAS, trawler; built by John Lewis and Sons, Ltd., for R. Irvin and Sons, Ltd.; length between perpendiculars 120ft, breadth 25ft, depth 12ft 6in; fish room capacity 7000 cubic feet, electric trawl winch, each barrel takes 1000 fathoms of 2¼in warp; Mirrlees "K.S.S.6" diesel engine, 712 b.h.p. at 220 r.p.m. Trial, November 14.

ESSO BRIXHAM, coastal tanker; built by Philip and Son, Ltd., for the Esso Petroleum Company, Ltd.; length between perpendiculars 185ft, breadth moulded 33ft, depth moulded 13ft 6in, deadweight 1070 tons, loaded trial speed 10 knots; four pairs of tanks, two 253 tons per hour diesel-driven cargo pumps, hydraulically operated deck machinery and steering gear; English Electric "8SRKM" turbo-charged diesel engine, service rating 657 b.h.p. at 675 r.p.m., drives propeller at 225 r.p.m. through oil-operated reverse reduction gearbox. Trial, November.

LONDON TRADITION, oil tanker; built by the Furness Shipbuilding Company, Ltd., for London and Overseas Freighters, Ltd.; length between perpendiculars 560ft, breadth moulded 80ft, depth moulded 42ft 3in, deadweight 24,950 tons, summer draught 32ft 4½in; twenty-seven cargo oil compartments, one main cargo pump room, three 1000 tons per hour turbine-driven cargo pumps, three 150 tons per hour steam-driven stripping pumps; two 325kW turbine-driven generators, one 100kW diesel-driven generator; one set of Richardsons Westgarths double-reduction geared turbines, 7300 service s.h.p. at 100 propeller r.p.m., 8200 maximum s.h.p. at 104 r.p.m., steam supplied at 450 lb per square inch and 750 deg. Fah. by two Foster-Wheeler "D" pattern water-tube boilers. Trial, November 20.

CALTEX NEWCASTLE, oil tanker; built by Hawthorn Leslie (Shipbuilders), Ltd., for Overseas Tankship (U.K.), Ltd.; length overall 559ft, breadth moulded 71ft, depth moulded 39ft 9in, deadweight 18,250 tons; twenty-seven cargo oil tanks, Butterworth cleaning system; two 450kW, 440V turbo-alternators, one 150kW diesel-driven generator; one set of Hawthorn Leslie double-reduction geared turbines, 8400 maximum s.h.p., two Foster-Wheeler "D" boilers supply steam at 600 lb per square inch and 950 deg. Fah. Launch, November 21.

Catalogues and Brochures

G. AND J. WEIR, Ltd., Cathcart, Glasgow, S4.—Pamphlets describing a two-element boiler feed regulator, and auxiliaries for nuclear power plant.

RUSSELL AUTO-FEED SCREWDRIVERS, Ltd., Studley, Redditch.—Illustrated leaflet giving technical details of the screw or pin driving machines manufactured by the company.

IMPERIAL CHEMICAL INDUSTRIES, Ltd., Imperial Chemical House, Millbank, London, S.W.1.—Booklet describing detonating relays developed by the Nobel division for short-delay blasting.

JOHN PICKLES AND SON, (ENGINEERS), LTD., Hebden Bridge.—Illustrated general catalogue containing 208 pages, describing a range of sawmill, woodworking, veneer, plywood and cooperage machinery.

SCOTMEC WORKS, Ayr, Scotland.—Leaflet describing the "Scotmec-Oxley" instantaneous moisture meter for measuring the moisture content of grain. The probe unit carries nine steel probes set in two groups; these act as electrodes, and for taking a measurement are thrust into the grain, through the sack. The probe unit is connected to an Ohmmeter which has a built-in generator. A 500V current is generated by turning a handle, and this is used for measuring the combined electrical resistance of the grain between the two groups of probes of opposite electrical polarity.

TIMBER DEVELOPMENT ASSOCIATION, 21, College Hill, London, E.C.4.—A new booklet entitled "Plywood" has been published by the Timber Development Association, containing a complete account of modern plywood for manufacturers and designers. Sections are devoted to the manufacture of plywood, its properties, adhesives, sizes, types and structural use. Many useful tables have been included and there are three appendices dealing with grading rules, principal types of plywood, blockboards and laminated boards, and notes on the general characteristics and properties of species of timber used in the manufacture of imported and British-made plywoods.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, March 28.—COVENTRY BRANCH: Craven Arms, Coventry, Films, "Electronics" and "Electronics in Industry," 8.15 p.m.

Sat., March 29.—NORTH LONDON BRANCH: Visit to the National Physical Laboratory, Teddington, 2 p.m. ★ YORK BRANCH: Visit to the English Electric Company, Ltd., Bradford Works, 10 a.m.

Tues., April 1.—SOUTH EAST LONDON BRANCH: Eltham Green School, Queenscroft Road, Eltham, London, S.E.9, "Photography in Research and Industry," P. B. Watt, 7.15 p.m. ★ TYNESIDE BRANCH: Crown Hotel, Clayton Street West, Newcastle, "Development of Power Cables," G. P. Cundall, 7.30 p.m.

Wed., April 2.—GLASGOW BRANCH: Institution of Engineers and Shipbuilders in Scotland, Elmbank Crescent, Glasgow, C.2, "Manufacture and Uses of Electric Cables," 8 p.m. ★ NORTH LONDON BRANCH: "Queens Head," 677, Green Lanes, Harringay, London, N.4, "Development and Research of Gas Turbine Engines," P. H. Calder, 7.45 p.m. ★ PRESTON BRANCH: R.A.F.A. Club, East View, Preston, "Modern Fixing Practice," R. P. Dunn, 7.30 p.m.

Thurs., April 3.—SOUTHAMPTON BRANCH: Pilgrim Room, Polygon Hotel, Southampton, "Capacitors Pay Dividends," 8 p.m.

BRITISH INTERPLANETARY SOCIETY

Sat., April 5.—Tudor Room, Caxton Hall, London, S.W.1, "Problems of Handling Large Missiles," F. R. F. Taylor, 6 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

To-day, March 28.—SOUTH MIDLANDS BRANCH: Winter Gardens, Malvern, "Transistors in Reception," L. E. Jansson, 7 p.m.

ILLUMINATING ENGINEERING SOCIETY

To-day, March 28.—BIRMINGHAM CENTRE: Regent House, St. Phillip's Place, Colmore Row, Birmingham, "Lighting in Relation to Modern Ceilings and Roofs," D. Phillips, 6 p.m.

Tues., April 1.—Northampton College of Advanced Technology, St. John Street, London, E.C.1, Conference on "Industrial Lighting," 10 a.m.

Wed., April 2.—EDINBURGH CENTRE: Y.M.C.A. Social Room, 14, South St. Andrew Street, Edinburgh, Annual General Meeting, 6.15 p.m.

INCORPORATED PLANT ENGINEERS

Mon., March 31.—WEST AND EAST YORKSHIRE BRANCH: The University, Leeds, Annual General Meeting, 7.30 p.m.

Tues., April 1.—LONDON BRANCH: Royal Society of Arts, John Adam Street, Adelphi, Strand, London, W.C.2, "A Small Generating Station and Its Relation to Process Steam Demands," B. E. A. Vigers, 7 p.m. ★ EDINBURGH BRANCH: 25, Charlotte Square, Edinburgh, "The Development of Diesel Traction on British Railways," V. Atkinson, 7 p.m. ★ PETERBOROUGH BRANCH: White Lion Hotel, Church Street, Peterborough, "Boiler House Management," O. H. Barker, 7.30 p.m.

Mon., April 7.—DUNDEE BRANCH: Mathers Hotel, Dundee, "The Uses of Electronics," R. B. Smith, 7.30 p.m.

INSTITUTE OF METALS

Tues., April 1.—OXFORD LOCAL SECTION: Department of Metallurgy, The University, University Museum, Park Road, Oxford, Annual General Meeting; At Home, 7 p.m.

Thurs., April 3.—LONDON LOCAL SECTION: 17, Belgrave Square, London, S.W.1, Annual General Meeting; "New Protective Coatings for Metals," W. E. Ballard, 6.30 p.m.

INSTITUTE OF PETROLEUM

Wed., April 2.—Lecture Theatre, 26, Portland Place, London, W.1, "Electrostatics and Explosion Hazards in the Petroleum Industry," A. Klinkenberg, 5.30 p.m.

INSTITUTE OF REFRIGERATION

Tues., April 1.—Junior Institution of Engineers, Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "An Experimental Study of the Use of Mixed Refrigerants for Obtaining Cooling Over a Temperature Range," G. G. Haselden and L. Klimek, 5.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Wed., April 2.—EAST MIDLANDS CENTRE: Mechanics' Institute, Nottingham, "The Work of the Motor Industry Research Association," W. G. Stevenson 7.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

To-day, March 28.—NORTH WESTERN BRANCH: 9, The Temple, 24, Dale Street, Liverpool, "Foundation Problems in the North Western Area," J. K. Alderman, 6.30 p.m.

Tues., April 1.—Great George Street, Westminster, London, S.W.1, "The Long Term Effects of Training Walls, Reclamation and Dredging on Estuaries," Sir Claude Inglis and F. J. T. Kestner, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

To-day, March 28.—RADIO AND TELECOMMUNICATION SECTION: Savoy Place, London, W.C.2, Convention on "Radio Aids to Aeronautical and Marine Navigation," 2.30 p.m.

Mon., March 31.—RADIO AND TELECOMMUNICATION SECTION: Savoy Place, London, W.C.2, "Future Radiocommunication Methods for Civil Aircraft," W. E. Brunt, 5.30 p.m. ★ MERSEY AND NORTH WALES CENTRE: Royal Institution, Colquitt Street, Liverpool, Annual General Meeting; "Colour Television," L. C. Jesty and E. L. C. White, 6.30 p.m. ★ NORTH EASTERN RADIO AND MEASUREMENTS GROUP: Rutherford College of Technology, Northumberland Road, Newcastle upon Tyne, Annual General Meeting, 6.15 p.m. ★ SOUTH MIDLAND CENTRE: James Watt Memorial Institute, Great Charles Street, Birmingham, Joint Meeting with Supply and Utilization Group, "Electrical Floor Warming," J. W. Moule and W. M. Stevenson, 6 p.m.

Tues., April 1.—EDUCATION DISCUSSION CIRCLE: Savoy Place, London, W.C.2, Discussion on "Economic Aspects of Electrical Engineering," opened by D. J. Bolton, 6 p.m. ★ NORTH MIDLAND CENTRE: Royal Station Hotel, York, "The Control and Instrumentation of a Nuclear Reactor," A. B. Gillespie, 7 p.m. ★ NORTH WESTERN CENTRE: Engineers' Club, 17, Albert Square, Manchester, "The Generation of Electricity in the London Area," H. V. Pugh, 6.15 p.m. ★ SOUTH EAST SCOTLAND SUB-CENTRE: Carlton Hotel, North Bridge, Edinburgh, "D.C. Winder Drives Using Mercury-Arc Rectifier/Inverters," L. Abram, J. P. McBreen and J. Sherlock, 7 p.m.

Wed., April 2.—TEES-SIDE SUB-CENTRE: Cleveland Scientific and Technical Institute, Corporation Road, Middlesbrough, "Some Transistor Input Stages for High-Gain Chopper-Type D.C. Amplifiers," G. B. B. Chaplin and A. R. Owens, 6.30 p.m. ★ SOUTH WEST SCOTLAND SUB-CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, "Ship Stabilization: Automatic Controls Computed and in Practice," J. Bell, 7 p.m. ★ SOUTHERN CENTRE: C.E.G.B. Offices, Portsmouth, "Junction Transistors," E. Wolfendale, 6.30 p.m.

Mon., April 7.—SOUTH EAST SCOTLAND SUB-CENTRE: Carlton Hotel, North Bridge, Edinburgh, "Broad-Band Slot-Coupled Microstrip Directional Couplers"; "Re-Entrant Transmission Line Filter Using Printed Conductors," and "The Application of Printed-Circuit Techniques to the Design of Microwave Components," J. M. C. Dukes, 7 p.m.

INSTITUTION OF ENGINEERING DESIGNERS

Sat., March 29.—NORTH EAST BRANCH: Visit to B.B.C. Television Transmitting Station, Pontop Pike, 2 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., April 1.—39, Elmbank Crescent, Glasgow, C.1, "Provision of Ore Handling Facilities at General Terminus Quay, Glasgow," A. Young and G. Gray, 6.30 p.m.

INSTITUTION OF HIGHWAY ENGINEERS

Tues., April 1.—EAST ANGLIA BRANCH: Assembly House, Norwich, Annual General Meeting, Films, 6.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, March 28.—INTERNAL COMBUSTION ENGINE GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, Discussion on "The Ultimate Engine: Stationary, Rail Traction and Marine," 6 p.m.

Tues., April 1.—LEONARDO DA VINCI LECTURE: 1, Birdcage Walk, Westminster, London, S.W.1, "Rockets and Guided Flight," A. D. Baxter, L. H. Bedford and G. W. H. Gardner, 10 a.m. and 2.45 p.m. ★ NORTHERN IRELAND BRANCH: Central Hall, College of Technology, Belfast, "Some Engineering Problems in Connection with the Industrial Application of Nuclear Energy," Sir Claude D. Gibb, 7.30 p.m.

Wed., April 2.—SOUTHERN GRADUATES' SECTION: Technical College, Reading, Film; Annual General Meeting, 7.30 p.m.

Thurs., April 3.—YORKSHIRE GRADUATES' SECTION: Grand Hotel, Sheffield, Discussion Evening, 6.30 p.m.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Tues., April 1.—Institution of Electrical Engineers, Savoy Place, London, W.C.2, "Long Term Planning of Telephone Exchanges," N. V. Knight and T. J. Morgan, 5 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

To-day, March 28.—WALES REGION: South Wales Institute of Engineers, Park Place, Cardiff, Annual General Meeting; "Nylon—A New Engineering Material," T. W. Currie, 7 p.m. ★ NORTH WESTERN REGION: Technical College, Abbey Road, Barrow-in-Furness, "The Electronic Control of Machine Tools," D. T. N. Williamson, 7.30 p.m.

Mon., March 31.—LIVERPOOL GRADUATE SECTION: Radiant House, Bold Street, Liverpool, Annual General Meeting; Films, 7.30 p.m. ★ NORTH WESTERN REGION: College of Science and Technology, Sackville Street, Manchester, "Ceramic Cutting Tools," G. R. Connor, 7.15 p.m.

Tues., April 1.—LONDON GRADUATE SECTION: 10, Chesterfield Street, London, W.1, "The Application of Spark Erosion Machining," A. J. Lawrence," 7.15 p.m.

Wed., April 2.—LONDON GRADUATE SECTION: Visit to Petters, Ltd., The Causeway, Staines, Middlesex, 2 p.m.

INSTITUTION OF RUBBER INDUSTRY

Mon., March 31.—LEICESTER SECTION: Bell Hotel, Leicester, Annual General Meeting; Short Papers Evening, 7 p.m.

Wed., April 2.—WEST OF ENGLAND SECTION: Melksham House, Melksham, Annual General Meeting, Films, 7.30 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

To-day, March 28.—MIDLAND COUNTIES BRANCH: James Watt Memorial Institute, Birmingham, "Prestressed Concrete," A. J. Harris, 6 p.m.

Tues., April 1.—LANCASHIRE AND CHESHIRE BRANCH: College of Science and Technology, Manchester, "The Structural Use of Reinforced Concrete in Buildings," M. E. Habershon, 6.30 p.m. ★ NORTHERN IRELAND BRANCH: College of Technology, Belfast, Film Evening, 6.45 p.m.

Wed., April 2.—NORTHERN COUNTIES BRANCH: Neville Hall, Newcastle upon Tyne, Annual General Meeting, 6.30 p.m. ★ LONDON BRANCH: 11, Upper Belgrave Street, London, S.W.1, Joint Meeting with Reinforced Concrete Association, "The Code of Practice for the Use of Normal Reinforced Concrete in Buildings," H. G. Cousins, 6 p.m.

INSTITUTION OF WORKS MANAGERS

To-day, March 28.—NOTTS AND DERBY BRANCH: Grandstand Hotel, Nottingham Road, Derby, "Brush Up Your Management," J. Bolton, 7.30 p.m.

Tues., April 1.—MERSEYSIDE BRANCH: Adelphi Hotel, Liverpool, Industrial Engineering Division, Discussion on "Limits in Work Measurement," opened by J. E. Faraday, 6.30 p.m.

Mon., April 7.—TYNE-WEAR BRANCH: Conference Room, Ministry of Labour and National Service, 93A, Grey Street, Newcastle upon Tyne, Annual General Meeting, 6.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, March 28.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "Photocopying and the Drawing Office," G. V. Rickards, 7 p.m.

Wed., April 2.—MIDLAND SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, Ladies' Night, "Modern Trends in Kitchen Housewares," 7 p.m.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Mon., March 31.—Lecture Theatre, Mining Institute, Newcastle upon Tyne, "Water Lubricated Bearings in Marine Use," A. D. Newman, 6.15 p.m.

PLASTICS INSTITUTE

Thurs., April 3.—SOUTHERN SECTION: Chemistry Department, The University, Southampton, "The Injection Moulding of Reinforced Plastics," J. Reece, 7.30 p.m.

REINFORCED CONCRETE ASSOCIATION

Tues., April 1.—MIDLAND COUNTIES BRANCH: Birmingham and Midland Institute, Paradise Street, Birmingham, "A Style of Building in Precast Reinforced Concrete," T. W. Beecham, 6 p.m.

Wed., April 2.—11, Upper Belgrave Street, London, S.W.1, Joint Meeting with Institution of Structural Engineers, "The Code of Practice for the Use of Normal Reinforced Concrete in Buildings," H. G. Cousins, 6 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Mon., March 31.—ORDINARY GENERAL MEETING: 12, Great George Street, Westminster, London, S.W.1, "The Preservation of Georgian and Victorian Architecture," J. Summerson, 5.45 p.m.

ROYAL METEOROLOGICAL SOCIETY

Wed., April 2.—SYMONS MEMORIAL LECTURE: 49, Cromwell Road, London, S.W.7, "Solar Radiation," C. W. Allen, 5 p.m.

SOCIETY OF CHEMICAL INDUSTRY

To-day, March 28.—CORROSION GROUP: The Robinson Lecture Theatre, The University, Manchester, "Recent Research on the Corrosion of Boiler Tubes," E. C. Potter, 6.30 p.m.

SOCIETY OF ENGINEERS

Mon., March 31.—Geological Society, Burlington House, London, W.1, "Soil in British Railway Civil Engineering," A. H. Toms, 5.30 p.m.